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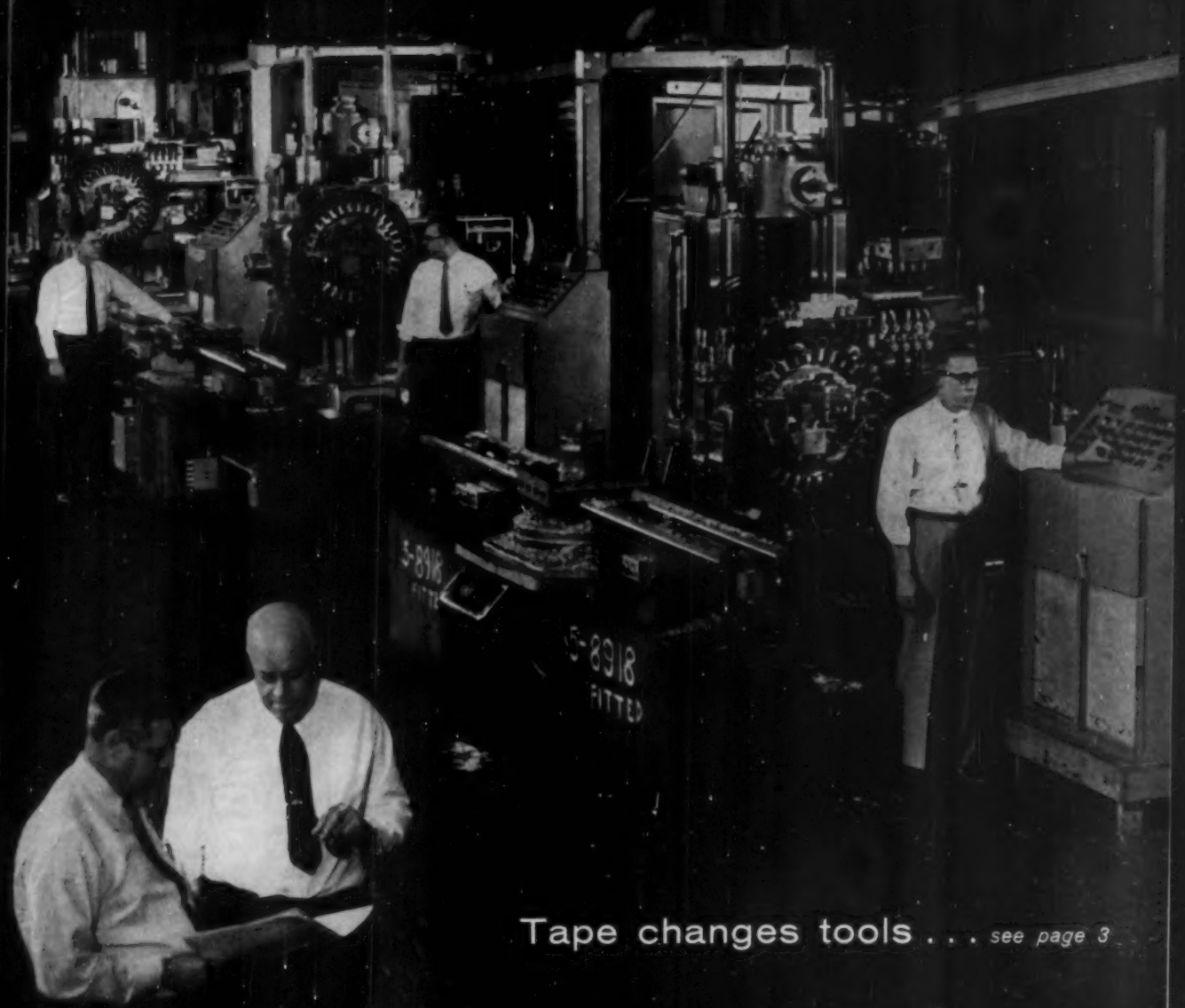
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · SEPTEMBER 5, 1960



Tape changes tools . . . *see page 3*

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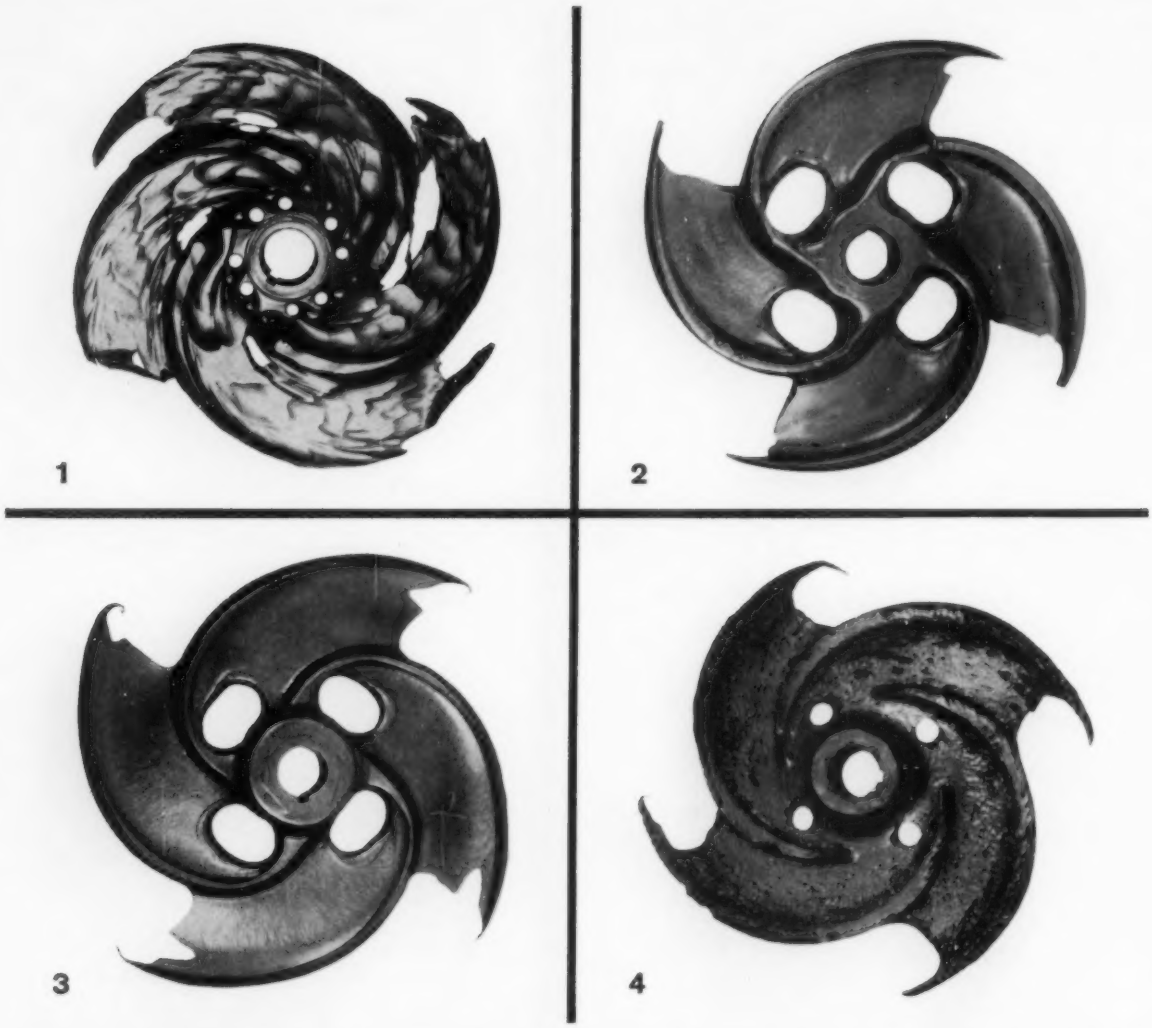

HOW GOOD A PUMP DETECTIVE ARE YOU?

Each impeller above is made of Worthite, an austenitic chromium-nickel-molybdenum stainless steel. Each was selected for its corrosion and abrasive resistance to the fluid being pumped. Each was in a pump correctly selected for the hydraulic problem to be faced. But each wore out long before necessary. Can you tell why by looking at the impellers?

In figure No. 1, the impeller handled lime mud in a paper mill. The deep gouges are caused by large chunks of lime. The feathered edges are caused by churning in the mud at start-up and when the suction tank was almost empty. Agitation of the liquid in the suction tank and by-passing solved the problem.

In figure No. 2, the Worthite impeller handled 65% potash slurry from the bottom of a thickener. It lasted 3 months. The percentage of solids was too high and the pump was operating at too high a capacity. By operating nearer the maximum efficiency and with a slight reduction in solids, the life of the impeller was more than doubled.

In figure No. 3, the impeller handled fine (48 mesh) potash slurry with some sharp sand. The pump flow was controlled by throttling the suction. By eliminating throttling of suction and installing a by-pass, impeller life was increased from one to about four years.

In figure No. 4, the pump delivered 50% by weight slurry to a plate and frame filter press. As the filter filled up, the pump operated back toward shut-off, causing wear on the outer third of the impeller vanes. The solution was to shut the pump down when adequate filter cake had been built up, but before the pump began to operate against shut-off. Impeller life increased three times.

Now, why did the impellers wear out long before necessary? It wasn't impeller material or pump selection. It *was* the system on which the pump was used. Seemingly small factors in installation or operation prevented achieving the full economy promised by Worthite in handling corrosive-abrasive fluids.

At Worthington we have been through these and virtually every other pumping problem. With the answers we've accumulated, we can help you avoid similar situations. For this help, contact your Worthington distributor listed in the yellow pages. Or write Worthington Corporation, Section 20-22, Harrison, N. J.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

September 5, 1960 Vol. 31, No. 36

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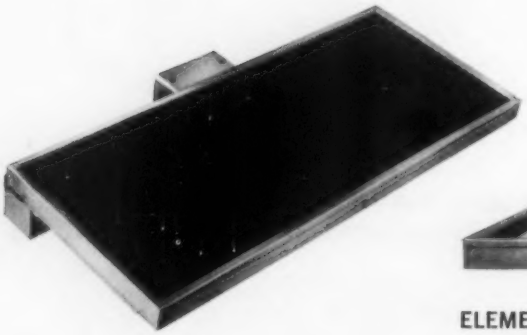
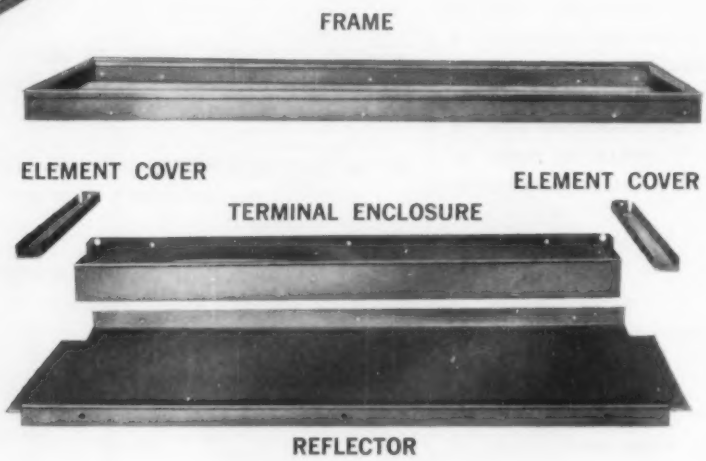
Economical, reflective Armco ALUMINIZED STEEL gives multiple benefits in new infrared heater



COMPLETE UNIT

This new self-contained infrared heating unit is used for drying, baking, curing, and preheating. The heating element is tempered glass coated with an electrically-conductive film. The long-wave-length heat given off is readily absorbed by materials of all colors. All major metal parts—reflector, frame, terminal enclosure and element covers—are made from Armco ALUMINIZED STEEL Type 1.



This new self-contained infrared heating unit heats quickly and uniformly, requires minimum maintenance, remains permanently strong—yet is built at reasonable cost. The reason: nearly everything except the glass is fabricated from Armco ALUMINIZED STEEL Type 1.

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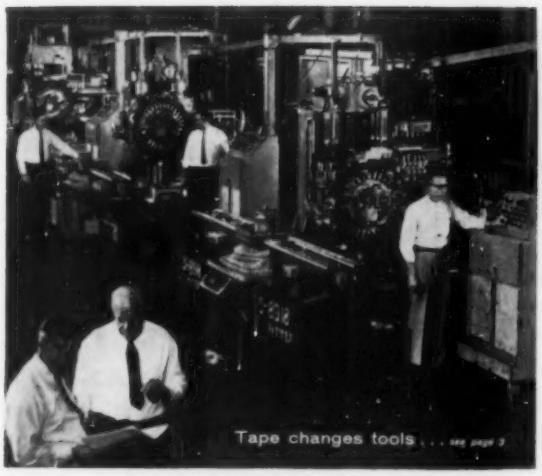

On our cover—The machine tool that changes its own tools. This "Milwaukee-Matic," produced by Kearney & Trecker in Milwaukee, bores, drills, reams and faces. In a drum beside the spindle are tools required. An arm, controlled by a tape, removes one tool from the spindle, and replaces it with one selected from the drum. Shown on our cover are three Model II machines in final assembly (at least 20 are in process at any one time). In the foreground, from left, are Bob Sedgewick, asst chief engineer, and Wally Brainard, chief engineer. Rear are Charlie Sipek, project engineer; Russ Clegg, mechanical engineer; and Ken Merner, electrical engineer. All are in the Numerical Control Division of K & T.

The picture, part of our series on engineers and their products, has a second reason for being. The Machine Tool Exposition is starting in Chicago, and will run this week and next. The show, which occurs only once every five years, is America's largest industry exhibition. Only members of the Machine Tool Builders Assn are allowed to display their wares. Nonmembers and foreign makers will display in a rival show at the Coliseum. And accessories, auxiliaries and tools will be shown at the Navy Pier. So there are three technical exhibitions in Chicago at the same time.

The last show, in 1955, drew more than 125,000 engineers and shopmen. Chicago's Transport Authority leased buses and drivers to transport people between Loop hotels and the stockyards. All this required 150 buses, 200 drivers and 25,000 gallons of gas to run 75,000 miles.

One new rule the NMTBA has established for this year's show—machine-tool orders must not be taken on the floor of the show. This rule will try to give the curious as well as the buyer opportunity to question engineers and sales personnel without being pressured into a commitment.

The Tail Tells

Recently, a London journal published a story informing its readers that a woman had been awarded £40 in court because her greyhound's tail curled like a watch spring. The man who sold the dog had told the woman

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that although the tail was curled while the dog was stationary, it straightened out when the dog began to run. However, the court awarded the woman damages when it was discovered that her greyhound couldn't straighten its tail at all. A racing dog with a curled tail is like a boat with a curled rudder—maneuvering is almost impossible.

Naturalists studying the speed of animals have come up with some rather interesting facts. For example, it has been observed that the American pocket-gopher's hind and fore legs are about the same length. This enables it to run backwards as readily as it runs forwards. Since the gopher spends most of his time cavorting within a labyrinth of underground tunnels, seeing where it's going while racing backwards might appear to be a problem. Not so. The gopher has a very sensitive tail, which bends downwards and warns of any obstructions.

Naturalists have spent a good deal of time clocking the speed of animals. Since accelerometers, like those mentioned on page 54, are not available for animals, a stopwatch and a measured distance must suffice. Here is a speed chart in miles per hour of some peak speeds by:

Cheetah	71	Greyhound	40	Elephant	25
Antelope	60	Rabbit	35	*Man*	25
Kangaroo	45	Deer	34	Camel	20
Horse	43	Giraffe	32	Pig	11
Lion	40	Rhinoceros	28	Mouse	4

Another Champ from Goteborg

Göteborg, Sweden recently gained fame as the home of a recent heavyweight boxing champion, Ingemar Johansson. It was also the early home of one of Sweden's greatest chemists, Karl Wilhelm Scheele, born in the mid-18th century when theories concerning the composition of matter and the definition of elements were in question.

Scheele worked in the back of his small apothecary shop. His only source of income was his store, and most of his profits were turned into equipment for his experiments; so he never had money to travel to the cities where he could meet others studying in his field. This prevented many of his discoveries from becoming known.

Scheele's notebooks show that he discovered chlorine and oxygen before Priestley, but he published his findings too late and never received credit. He was an unknown, and letters he sent to learned societies remained pigeonholed for long periods; often they were forgotten entirely. Among his discoveries were glycerin and uric acid. His process for purifying and isolating organic acids is still in constant use.

For years the element molybdenum had been confused with graphite. Both are black and have good lubricating qualities (see article on page 48). Scheele was the first to show that graphite is a form of carbon while molybdenum comes from the ore molybdenite.

One of Scheele's most remarkable achievements was his studies of Prussian blue. This led to, among other things, the preparation of hydrocyanic acid. In his paper Scheele describes in detail the acid's odor, peculiar taste and the "warm sensation it gives in the mouth." However, nothing was mentioned about its high toxicity. Scheele must have led a charmed life to have survived this empirical discovery of prussic acid. —Benedict A. Leerburger, Jr.

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Which Heat Protector for the Motor?**

Here, for the first time, are all factors affecting response and accuracy of thermal-protection systems.

. . . **Belleville Springs for Constant Braking Power**

In this new configuration, braking force is unaffected when lining wears. The springs also permit lighter construction, avoid overheating.

. . . **Quick Calculations for Corrugation Stiffness**

Equations and graph find moment of inertia and location of neutral axis for a wide range of cross-sections.

. . . **Dimensional Stability in Precise Parts**

To retain accuracy in mechanical parts you must know how metal properties are changed by service stress and temperature.

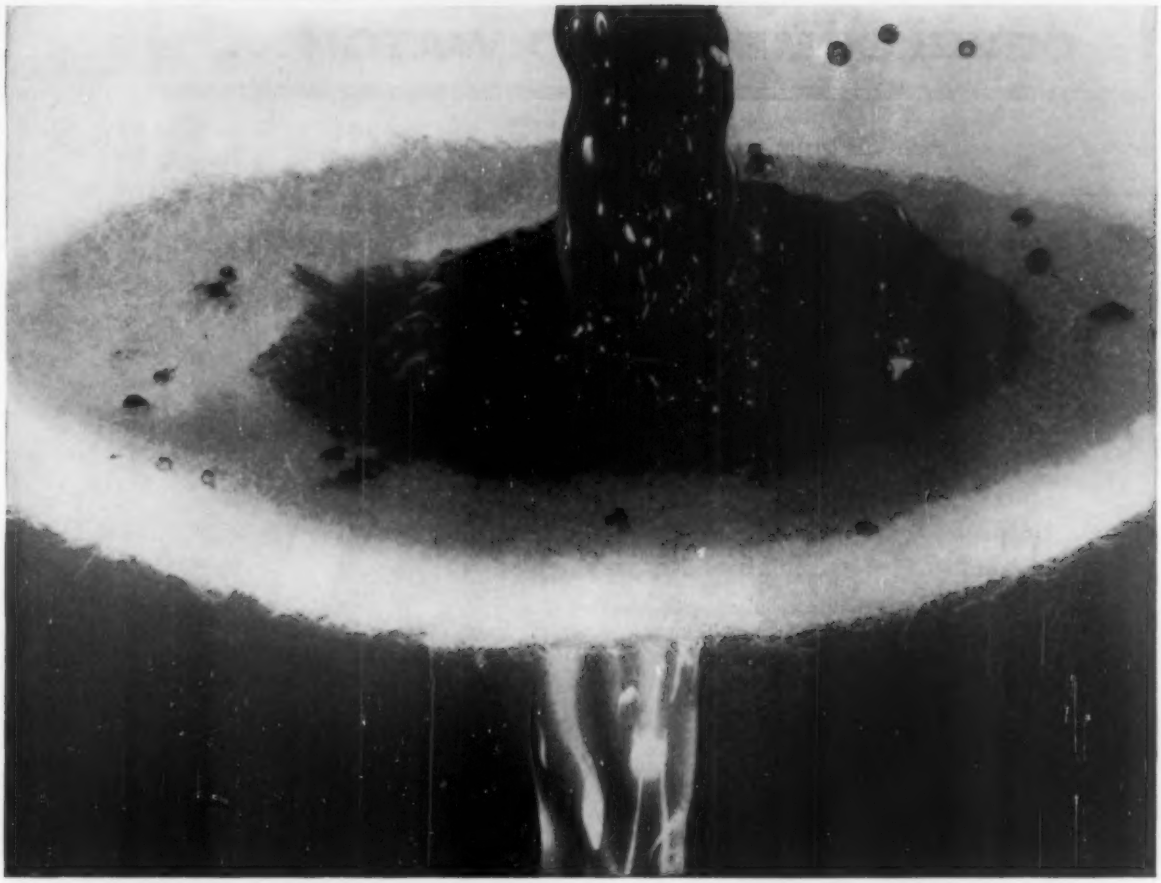
. . . **How Are Our Engineering Schools Meeting the Challenge?**

Dr Gordon S. Brown, Dean of Engineering at MIT; gives Product Engnieering his point of view.

. . . **Data on Human Engineering**

What's available and where to get it. A bibliography of the more generally useful and significant printed information.

An example of Avisco Rayons in Industry



Why rayon fibers are rapidly gaining in filtration applications

Avisco rayon fibers have been making giant strides in filters for smoke, air and liquid filtration. Why? Because they can be engineered to meet specific filtration needs . . . plus low cost and filtration control.

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DEVELOPMENTS TO WATCH . . .

Better circuit components promised by new laminates

Clean-punching phenolic laminates, free of such difficulties as blistering and solvent extraction, have been produced experimentally at the Westinghouse Research Lab "in sufficient thickness to be of interest as base materials for use in printed circuits."

The laminates can be punched at or near room temperature (5 min. in an oven at 180 F is usually more than sufficient), and their electrical properties are very good. Dielectric constant at 60 cycles ranges from 4.7 to 5.0 for those materials with highest punch rating.

Furthermore, J. H. Freeman and E. J. Traynor say in a report prepared for the American Chemical Society, the same polymers "also possess ability to be made into a satisfactory grade of post-formable laminate, free of added plasticizer."

Westinghouse emphasizes that the materials are not yet commercial, and not available for evaluation. But it is expected that commercial products will be developed as the work progresses.

New compound to improve paints and papers

A water-soluble cellulose with excellent film-forming and stabilizing properties is now under test at the Tennessee Eastman research labs. Technically known as **sodium cellulose acetate sulfate**, it's headed for applications in such diversified fields as emulsion paints, cements, textile and paper sizes, and soluble packages. In film form, it's strong, flexible, nonflammable and oilproof, yet retains the water-soluble property. Eastman Chemical emphasizes that it's still a development item not yet ready for commercial application.

High-temperature fiber readied for new jobs

Unusually high surface area, plus heat resistance to 2200 F and desirable electrical and acoustical properties are opening new applications for potassium titanate fibers, says DuPont's Pigments Dept.

This inorganic fiber, first announced about two years ago (*PE*—Nov 17 '58, p 44), is now in semi-works production, and has just undergone a substantial price cut (loose fiber down from $16.50 to $5.10 a lb; with corresponding reductions for blocks and sheets), and new technical data is being made available.

The fiber can be molded, used as a filler to increase the dimensional stability of plastics (Teflon, for instance) or pressed into mats. Suggested applications range from electrical, thermal and acoustical insulation to fillers and ablation coatings.

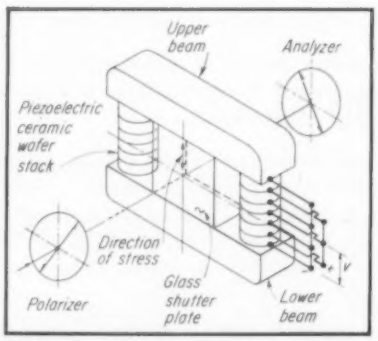
New optical shutter based on dimensional change

An ultrahigh-speed shutter, basically a mechanical analog of the Kerr chemical shutter (*PE*—Oct 7 '57, p 15 and Jan 13 '58, p 5) is being developed by Electro-Optical Systems Inc.

It takes advantage of the fact that, under the influence of an impressed voltage, piezoelectric materials will expand or contract. Thus, a glass shutter plate mounted between rigid bars supported by stacks of piezoelectric ceramic wafers (see diagram) will be stressed as the wafers change in size, causing a temporary double refraction that momentarily shuts off polarized light.

Speeds on the order of 100 microsec have been achieved, using a 3000-v source.

continued, p 8



GLASS PLATE serves as shutter in new optical device that uses a polarized light source, with piezoelectric ceramics as operating means.

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In designing for air operation, the engineer can choose the method of valving he prefers—and still have all the advantages of integral valve and cylinder construction.

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If he prefers to use 8-12 volt electrical control with its simplified wiring, Bellows has it. If he prefers to use 115 volt control and JIC standards, Bellows has it. If he requires low or high voltage explosion-proof control, Bellows has it. Should his design require full pneumatic control, Bellows has it. Or should he wish to control his pneumatic circuits manually or through mechanical linkage or cams, Bellows has it.

Unlike conventional air cylinders which require separate remote directional and speed control valves and dual piping, the Bellows Air Motor is a complete power unit with directional valve and dual speed control valves built-in as an integral part of the unit. Only one air connection, which can be made with flexible hose, is required.

Integral valve and cylinder construction means quick response, more positive response, more precise control and more economical operation.

The Bellows Air Motor is made in five bore sizes: 1¼", 1¾", 2½", 3⅝", and 4½", and in any stroke length.

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DIVISIONS OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

Better extrusions promised by improved forming technique

A pressurized fluid sheath can prevent cracking of magnesium, beryllium, bismuth and other nonferrous metals during extrusion, the National Engineering Laboratory of Glasgow, Scotland reports.

By surrounding the metal with fluid under high pressure, it seems possible to increase the ability of the material to absorb stresses and so reduce the danger of surface cracking.

The process is not yet ready for commercialization; but NEL believes that it does hold commercial potential—at least for the three metals noted above, for which pressures of 20 to 30 tons/sq in. are sufficient. Other nonferrous metals—brass, for instance—would require such extremely high pressures (50 tons/sq in. or more) that commercialization may not be feasible. On the other hand, the process may prove adaptable to beryllium and other "new" metals.

Chemicals that change color may collect data

A new type of photochemical "memory," suitable for use in computers, is claimed by Prof Yehuda Hirshberg of Weizmann Institute. Writing in Britain's *New Scientist*, he claims his *photochromic* technique represents a third route to reversible color change, the other two being thermochromism and phototropism. (The former change color when heated; the latter when exposed to ultraviolet light.) The new materials in some ways combine the two effects. They become strongly colored when exposed to ultraviolet light at ultralow temperatures (−76 to −283 F), and then revert to their original state when the temperature approaches normal.

Both phototropic and thermochromic materials have been found to exhibit this photochromic effect, so already-known materials can be used in designing photochromic components. Furthermore, some compounds have been found which exhibit multiple color changes as the temperature rises—one going from green at −283 F to rose at −256 F to violet at −138 F, and then becoming colorless at room temperature. In addition, one group of recently developed compounds change color when exposed to ultraviolet light, but turn colorless in visible light. This is the type expected to be most useful in computer memories, since the color change can be made to occur at very high speed.

Tachometer senses speed without contact

A tachometer that measures rotary speeds by monitoring changes in capacitance has been devised by Guenther Industrial Developments Ltd, London E 14, England. The basic principle is simple: A transducer senses the change in capacitance each time an irregularity on a rotating shaft passes close to a probe or pickup. The "irregularity" that actuates counter may be a spline, keyway, or even a gear.

The unit, housed in a case 6½ x 9 x 9 in., contains amplifying, pulse-forming, triggering, and binary circuits to convert voltage pulses from the sensing probe into constant-amplitude signals independent of shaft diameter and size of the irregularity. Counting circuits provide a dc output proportional to the rotating speed; and this operates a moving-coil indicator calibrated in rpm. The unit has 6 speed ranges with, Gruenther says, better than 2% accuracy in each range. Its price: about $190 (UK equivalent). —ARG

BRITISH TACHOMETER features interchangeable probes, compact supply unit. It can be adapted for batch counting and automatic control.

WHAT'S HAPPENING IN RESEARCH . . .

Tests pave the way for tougher plastics

What makes some plastics impact-resistant, while others are not?

From Case Institute come new ideas that may provide the answer:

Data have been collected on shear modulus and damping as a function of temperature change for a number of plastics, and electron microscope examinations have been made of fracture sections.

The tough plastics show a rubbery type of stress-relaxation behavior at strains exceeding the yield value, while the brittle ones do not. And the tougher materials have highly textured rather than smooth fracture sections.

The transition from glassy to rubbery behavior when strain is induced at high speeds seems to depend on a fracture-healing mechanism which functions only in plastics having a polyphase or domain structure made up of both glassy and rubbery components.

R. M. Evans and E. G. Bobalek of Case plan to present a full report at the ACS meeting next week on work done so far.

Research boom in heat-resistant polymers

The ultimate goal is still a long way off: commercial production of semiorganic and inorganic "plastics" that will stand 1000 F or more. But researchers from many laboratories are reporting real progress in the right direction.

From Carnegie Institute of Technology comes a report by Robert R. Holmes on a new route to phosphorus-nitrogen compounds that opens the way for polymers "that may possess properties more desirable than those obtainable by present methods.

Still in progress, too, are many studies of boron and fluorine compounds (*PE—Sep 7 '59, p 13 and July 7 '58, p 17*).

None of these match the 1830-F claims of British researchers (*PE—July 18, p 6*) but these compounds are being fully described, while little information is available on the British materials.

Cerium sulfide: Ultrahigh-temp semiconductor?

For service in the 1020- to 2600-F range, cerium sulfide looks like a promising semiconductor material, says General Dynamics Corp. Its General Atomics Div has been working with n-type cerium sulfide and says "the material is sufficiently optimized to give ZT's (figures of merit) of 0.1 and above."

Also under study—for the same temperature range—are p-type thalium sulfide semiconductors.

The work is still in its early stages, and there are problems in obtaining information on such properties as thermal conductivity at these temperatures since it is necessary to work with such small wafers. However, a new small-area contact system developed at General Atomics may help solve this problem. The technique itself was described by S. W. Kurnick, R. L. Fitzpatrick, and J. F. Leavy of General Atomics at last month's AIEE Pacific Meeting.

Alloys that change as they work

A "chain" reaction explains the effectiveness of one recently developed alloy for nuclear reactors. The alloy is a silver-indium-cadmium combination developed for control rods (*PE—May, 16, p 8*). In a report prepared for the AEC, General Nuclear Engineering Co notes that, in use, it can actually gain in corrosion resistance.

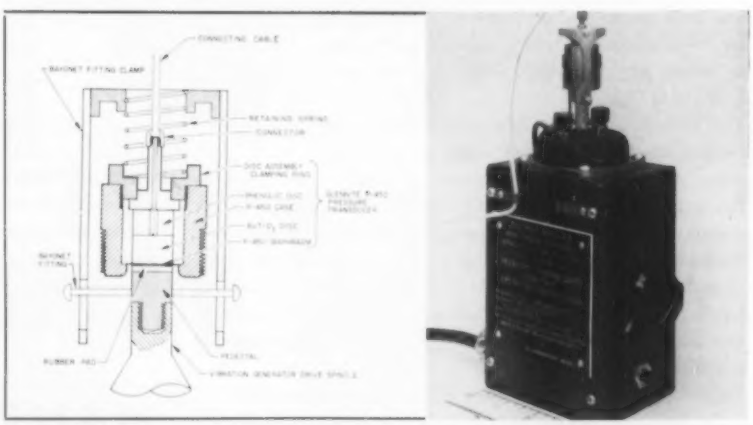
The reason: Under irradiation, all three elements in this alloy undergo transmutation. The silver is partly converted to cadmium, the cadmium to indium, and the indium to tin. Thus, an 81.5-13.6-4.9 alloy turns into a 61.5-12.1-9.4 alloy with 2% tin—a composition that has been found to have even better corrosion resistance than the original.

Most other alloys do the reverse; or improve in one characteristic while being markedly reduced in others. Boron-bearing steels, for instance, become stronger and stronger but lose almost all their ductility. —ARG

For testing a transducer

This calibrator for pressure-measuring systems simulates, with the aid of a vibrating reed, the effects of pressure on a transducer, creating a sinusoidal wave that follows the $F = ma$ pattern.

It's a portable, hand-held unit, designed for field-testing transducers, and they can be coupled to the testing machine just as they are to the instrumentation system in which they are used. The diagram shows essential construction features; and the picture, a prototype model designed by Eric Rule and Thomas A. Perls of Lockheed Aircraft Corp.



CALIBRATOR for pressure-measuring systems was designed at Lockheed.

FOR SHEER, SHEAR STRENGTH

Hydraulic Pressure tests on Bridgeport Brass Company's patented cladding system show perfect no-leak bonds over 3000 psi.

...*Bridgeport Brass Uses EASY-FLO 45 to Bond Their Clad Metals*

The "thick and thin" of cladding—from .010 to 2¾" in a combination of ferrous and non ferrous metals—calls for a bonding agent that will hold under the most severe forming and service operations. The answer, in every respect, is Handy and Harman's silver brazing alloy, EASY-FLO 45.

The uses to which these clad metals are put range from the kitchen to power plants, refineries, chemical and food-processing installations. Famous Bridgeport Copperware, used by housewives throughout the country, is made from a triple-clad metal consisting of a sandwich of two sheets of .010 stainless steel bonded to both sides of a sheet of .025 copper. The metals are joined in Bridgeport's patented process at *finish gauge*. So strong is the bond that no difficulty is encountered in the forming operations which follow.

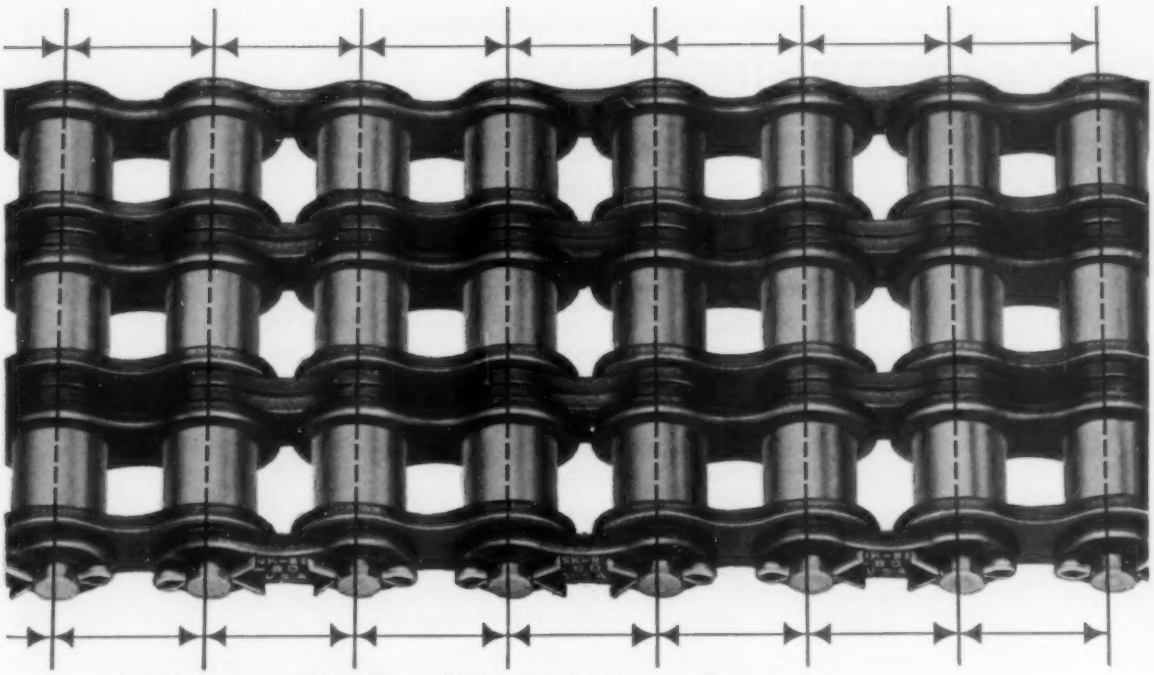
Tube sheets, though their uses are far from "domestic," require the same "bondability." Tests at Bridgeport show that shear strength exceeds 20,000 psi. And this involves the cladding of carbon steel to as many different metals as stainless, brass, Monel and copper.

The primary need here, of course, is strength. EASY-FLO 45 has other attributes that are more than welcome under *any* metals-joining conditions: thermal and electrical conductivity, gas- and liquid-tightness, ductility, ease of application and economy are some more that we'd like you to know more about. We are ready indeed to further acquaint you with the significant benefits of silver alloy brazing by sending you our Bulletin 20, which is a clear and comprehensive introduction to one of the simplest, *saving* metals-joining methods in existence. Handy & Harman, 82 Fulton Street, New York City 38.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HH

HANDY & HARMAN



Precision controlled link pitch throughout
LINK-BELT roller chain means

equal length... equal strength

How pre-stressing ensures uniform load distribution of multiple-width LINK-BELT roller chain

Pre-stressing is one of the reasons why Link-Belt multiple-width precision steel roller chains easily handle the grueling loads common on today's drives. It seats and cold works the chain joint parts, assuring equal load distribution across the chain, minimum initial elongation, increased fatigue life.

Pre-stressing is just one of many "extras" that contribute to the *greater dynamic strength* of Link-Belt roller chain. Others include: close heat-treat control, lock-type bushings, shot-peened rollers, pitch-hole preparation. For details see Book 2657.

PRE-STRESSING MACHINE provides the pull that "sets" the parts of Link-Belt multiple-width roller chain. Besides assuring uniform load distribution, pre-stressing eliminates application difficulties on fixed center drives because the chain leaves the factory at precise operational length.

BOOK 2657 has 154 pages of roller chain data. Contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.)

LINK-BELT

ROLLER CHAINS AND SPROCKETS

15,361-A

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

FROM WASHINGTON . . .

ARPA undertakes basic research in energy conversion

A new program to explore energy conversion has been launched by the Dept of Defense's Advanced Research Projects Agency (ARPA). Dubbed Project Lorraine, the program will support basic research—not applied research—in energy conversion.

The purpose is to intensify research into basic processes that now are a mystery to engineers and scientists. For instance, they want to discover how plants use sunlight to convert one group of chemicals into another.

Right now, boron-doped silicon cells are the best solar cells in use. However, ARPA thinks that organic materials such as polynuclear aromatic hydrocarbons offer better potential if research can prove them out.

Studies of organic-energy conversion will be the first to be funded by Project Lorraine. Details on the program are still being worked out. Actual letting of the contract will be done thorugh the Air Force's Cambridge Research Center. Indications are that ARPA will spend around $200,000 a year on the organic-energy research, with several universities getting a slice of the money.

In all, the Lorraine program is expected to fund around 50 projects on a continuing basis at a total cost of around $5 million a year. The average contract likely won't run more than $100,000, however. ARPA received the go-ahead on Project Lorraine about a month or so ago. It is something that engineers and scientists have wanted for some time. The reason is that bulk of the effort going into energy conversion has been channeled into inorganic approaches.

Working from the organic approach offers wider potentials, many engineers claim. Under Project Lorraine, these can be explored, and it will enable universities to train additional engineers and scientists in this field.

ARPA will work closely with the three military services, the Atomic Energy Commission, NASA and the Bureau of Standards. The selection of just which projects to support will be done on a joint basis with all agencies. In addition the RAND Corp has a standing contract with Dept of Defense for this type of study and evaluation. Once ARPA decides to fund a program it will be turned over to one of the services to administer.

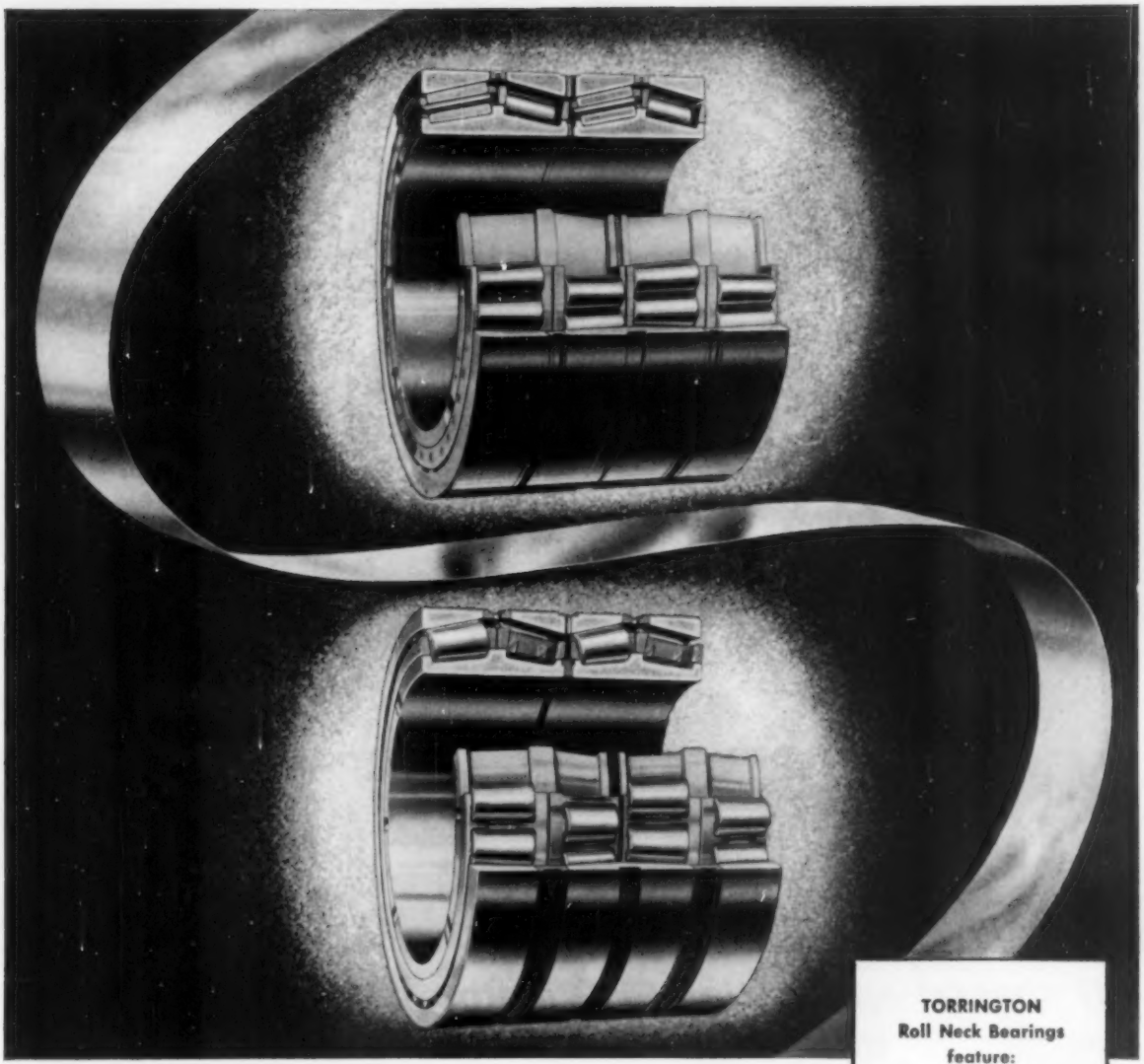
Thermocouples to replace gears in sub refrigeration systems

Submarines will soon be equipped with refrigeration systems using thermocouples. That's the Navy's prediction. Noise reduction is the big motive for such a system, Navy spokesmen say. By eliminating all gears in the air-conditioning and refrigeration system, Navy will move a notch closer toward licking one of its biggest submarine problems—detection by the enemy.

Cost of Navy's new refrigeration system will run several times the $200,000 or so for a conventional submarine refrigeration system, the Navy says. But it won't reveal actual dollar figures for the thermocouple arrangement. Costs may drop some when the systems go into production. For one thing, Navy points out, the cost of such metals as bismuth and tellurium used in the thermocouple arrangement should drop when larger quantities of the metals are used.

Companies such as Westinghouse, York, Carrier and Whirlpool are working on the Navy project. Right now, Navy says it could build a system 1/4 to 1/3 as efficient as a conventional Freon system.

A working model is slated to be built soon, and Navy says submarines will be equipped with the thermocouple system in the next couple of years or so.



TORRINGTON
Roll Neck Bearings
feature:

- carburizing grade alloy steels
- advanced heat treatment
- minimum cross section
- high radial and thrust capacity
- resistance to shock loads
- precision manufacture
- grooved cone faces

Keep tonnage rolling... with Torrington Roll Neck Bearings

Tonnage rolled per turn and downtime saved—these measure bearing performance in metal rolling mills.

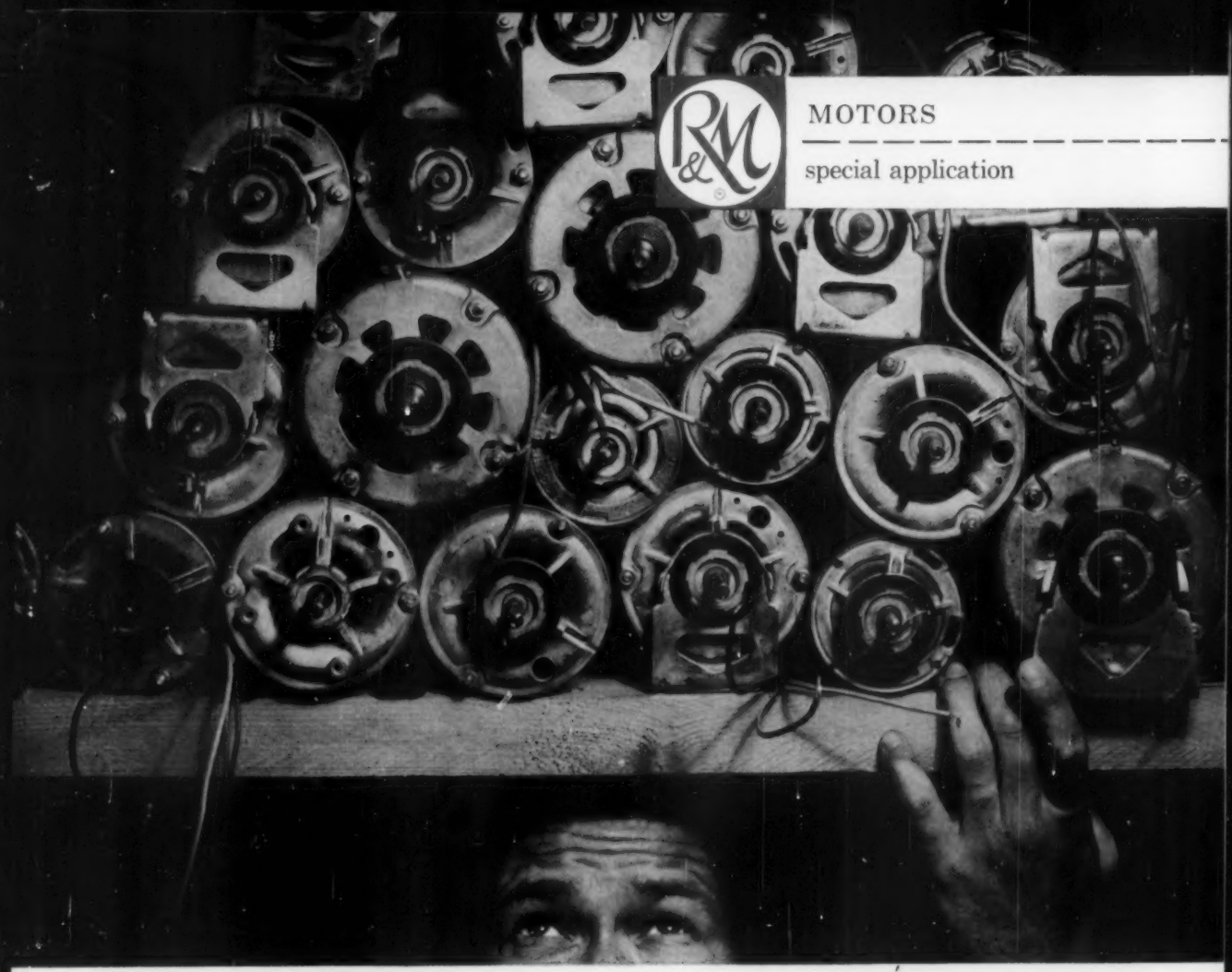
Torrington Roll Neck Bearings are designed for top performance under tough conditions. Maximum capacity and exceptional life expectancy are combined in bearings that operate efficiently under the severest thrust and radial loads. Torrington's advanced heat treating of carburizing-grade steels provides optimum resistance to wear and shock loads. Lubricant grooves on cone faces minimize roll neck galling under creep conditions.

When you choose Torrington Roll Neck Bearings you can be sure they will pay off in more steel production at lower cost. More than a quarter century of experience in anti-friction bearing engineering for metal rolling mills—makes Torrington quality a byword in the industry.

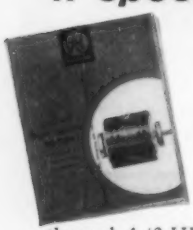
progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

CIRCLE 13 ON READER SERVICE CARD 13



if special application FHP motors are on your mind... write for R&M's new Bulletin 445

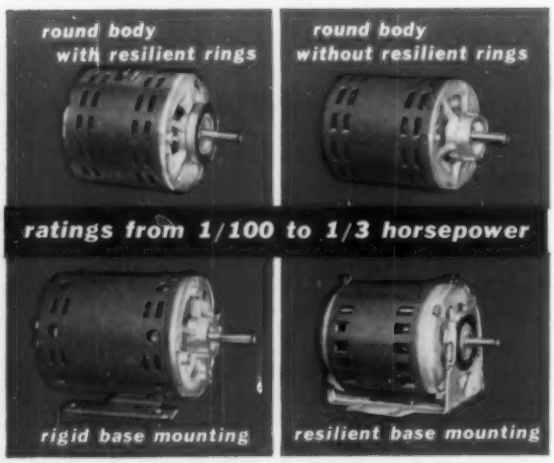


This informative bulletin illustrates and describes in detail Robbins & Myers broad new line of Special Application FHP Motors.

You may select from four frame sizes, sixteen ratings from 1/100 through 1/3 HP, three different pole constructions, three standard mounting arrangements and four electrical types.

Simple, compact and quiet, these motors offer built-in benefits for your customers, as well as design flexibility for you, where silent operation, limited mounting space and minimum attention are factors.

Also, should your requirements be so special that a custom designed motor is indicated, our expert application engineers, using the most modern electronic computers, can promptly select the optimum design for your special requirements. Write today for your copy of R&M's new bulletin 445PRE.


round body with resilient rings
round body without resilient rings
ratings from 1/100 to 1/3 horsepower
rigid base mounting
resilient base mounting

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators

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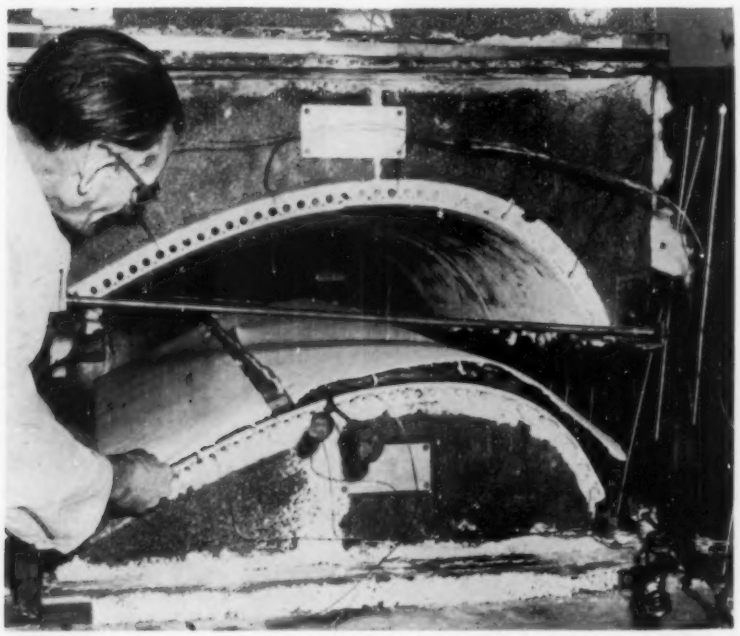
CIRCLE 14 ON READER SERVICE CARD

THE ENGINEERING WEEK



CORES AND OUTER PANELS of stainless are placed between Avco's ceramic platens prior to brazing cycle (note electrical heating elements and cooling holes in the platens). After sealing, subzero temperatures are possible for cooling of ceramic and honeycomb sections.

Brazing Process Cuts Cost of Stainless Sandwich

NASHVILLE, TENN. — Honeycomb sandwich sections of stainless steel, in almost any shape or size and to close tolerance, can be brazed at significant cost savings over present-day techniques, says Avco Corp's Nashville Div. Its claim is based on a new fabricating technique—called Avcoramic—and a ceramic material developed by Avco. Early work on the material was done at Avco's Research and Advanced Development Div.

President John Mihalic of the Nashville Div says, "By accomplishing the entire brazing, conditioning and aging cycle in a single tool, lower costs are possible." The material, he adds, has excellent resistance to thermal shock, can be cast with tolerances of 0.003 in., and worked to any required shape with a minimum of effort.

Process works like this. Brazing platens are made from the ceramic material to any shape or size. Holes are formed through the material both for heating elements and cooling purposes. Ceramic surfaces are then finished to close tolerances and act as contour forms for brazing the stainless honeycomb. Sandwich material enclosed in a stainless steel envelope is placed between the matched platens. Close contact of the parts to be brazed is assured by maintaining a vacuum in the envelope and an external pressure on the ceramic platens.

Ceramic material is heated electrically to the proper brazing temperature and held for a controlled time. Then platens and honeycomb are cooled rapidly by air forced through the platen holes. Finally, for maximum strength, the panels are aged at an elevated temperature.

Immediate use of the process is for space vehicles, missiles and supersonic aircraft, but Avco says the low cost makes other applications feasible. ■

Failure Rate Almost Zero for New Resistors

PHILADELPHIA—Resistors having a failure rate no greater than 0.0004% per thousand hours of operation have been announced by International Resistance Co here. The components were developed for the Minuteman missile guidance and control system under development at North American Aviation's Autonetics Div.

The resistors are an evaporated metal-film type, made completely of inorganic materials. They are hermetically sealed in glass and have power rating, based on full load operation, at ambient temperature of 125 C (257 F).

Besides being built to last, the resistors are said to meet rigid performance standards. In tests for low-temp operation, hi-temp exposure, short-time overload, acceleration, high-frequency vibration, terminal strength and dielectric withstanding voltage, they are allowed a change in resistance not exceeding ±0.25% plus 0.05 ohm. Change in resistance between initial measurement of load life and any succeeding measurement may not exceed ±0.5% plus 0.05 ohm. Resistance is within 1% of nominal.

IRC engineers base their success mainly on development of special production techniques. Ordinary procedure, they say, makes a component, then tests it against standards; IRC builds in reliability throughout the production process.

PRODUCTION BY COMPUTER

Basic to this process is a detailed life history of each resistor—each is assigned an IBM card. As materials are assembled, detailed data on the individual component is entered into the computer. This data includes such information as chemical composition and trace impurities found in the constituent materials. Periodically, data for resistors in progress is compared with that of other resistors. If any differs from its neighbors, it's automatically discarded.

When a resistor is shipped, its IBM card accompanies it—so that if the resistor should fail, IRC can check back in the computer record and use

the information to improve reliability of subsequent models.

Among other production processes developed by IRC to ensure quality is a device to detect flaws by radioactive gas. It spots any leak large enough to permit one billionth cc of gas to pass out.

Though resistors of extreme reliability are required primarily in missiles, IRC engineers say some of their research data may help them develop more reliable resistors for computers and other applications using complex electronic systems. ■

Explosive Charge Powers Missile Gyroscope

WILMINGTON, DEL.—Very tiny precision explosives have been developed by Hercules Powder Co to drive gyroscopes for short-range missiles. The 3-gram charge is hermetically sealed inside the gyroscope and ignited electrically.

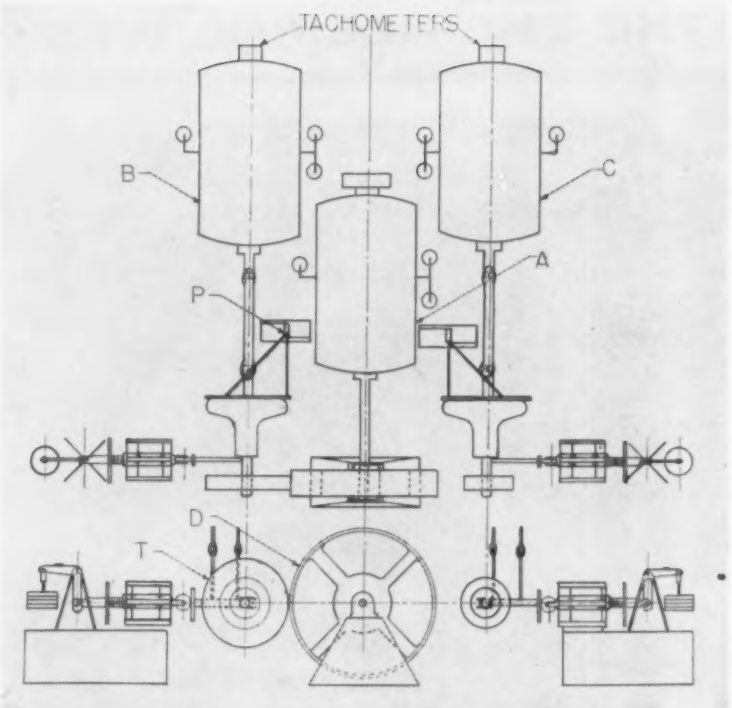
Gases generated by the burning propellant escape through holes to provide the jet impulse, which, according to Hercules sources, brings the rotor up to speeds exceeding 36,000 rpm within 0.1 sec after the charge ignites. The charge is said to give effective performance for a period up to 4 min., and to operate in a temperature range from −85 to 167 F.

The gyro assembly weighs 0.5 lb. Weight reduction is attributed in part to elimination of the clock-type spring that activates similar gyroscopes. ■

Super-cold Refrigerator To Aid Cryogenic Studies

BOULDER, COLO—A new continuously operating, super-cold refrigerator, capable of supplying constant temperatures in the vicinity of −452 F was described at the 1960 Cryogenic Engineering Conference at the University of Colorado here.

This closed-cycle refrigeration system is 9 in. dia and 28 in. long. Weight is under 100 lb. Constant temperatures can be maintained to ±0.06 deg C. If liquid nitrogen is used for precooling, a typical system can be brought to operating temperature within 5 hours. The system achieves the effect of a series of expansion engines operating at different temperatures, yet it uses only displacers and two valves. ■



TO MEASURE POWER LOSS of a tire (T), NBS connects an absorption dynamometer (A) to a steel drum (D); drive dynamometers (B) and (C) power truck and passenger tires, respectively. A ball-and-socket pivot (P) aligns plane of tire with plane of drum. Instrumentation of dynamometers permits measuring speed to within 0.1 rpm, and torque to within 1% of difference between input and output values. Absorption (tractive) dynamometer operates as generator, has 60-hp capacity at 250 rpm; other dynamometers operate as motors, with 40-hp capacity at 250 rpm.

NBS Runs Down Causes of Tire Trouble

WASHINGTON—A National Bureau of Standards study of tire power loss—which contributes to premature tire failure—shows construction and type of rubber are the main factors determining how power loss varies with speed, load and inflation pressure.

Tires were first preconditioned by rotating against a drum for 16 hr at 45 mph under 80 to 100% of maximum load. Then the load, speed, and inflation pressures were adjusted to the desired values; the axle of the rotating tire was made parallel to the axle of the drum; and the tire was run until temperature of the contained air remained constant. Readings were taken of the dynamometer torques, speed and inflation pressure; the temperature of the ambient air and of the contained air. For convenience in comparing the tires, the rolling-resistance coefficient, R—a dimensionless quantity—was used. ($R=P/SL$, where P is power loss in ft-lb/min., S is speed in fpm, and L is the load in lb.)

VARIABLES STUDIED

In the present study, experiments were conducted at speeds of from 5 to 50 mph, under constant loads of from 1000 to 5000 lb, and inflation pressures of from 60 to 120 psi. Rolling-resistance data were compiled for tires ranging from 7.00-15 passenger-car size to 11.00-20 truck size; constructed either of natural or synthetic rubber, or a combination of both; containing 1 of 7 different kinds of carbon black; and having rayon, nylon, or steel-wire cords.

Analysis of the data showed rolling-resistance coefficient of passenger types was greater than of truck tires. Effect of inflation pressure on R was practically independent of speed at normal loads, but markedly depend-

ent on speed at low loads. In the truck tires studied having either nylon cord or steel-wire cord, a decrease in R occurred with increasing speed; tires with rayon cord showed either no change or a linear increase in R with increasing speed. In passenger-car, R increased at a growing rate with increasing speed, particularly in a rayon-cord tire. R increased with load in all but steel-wire-cord truck tires, according to the report.

RUBBER HAS PRONOUNCED EFFECT

The type of carbon black had little or no effect on R; however, rubber type had a pronounced effect—natural rubber showed lower power loss than styrene-butadiene synthetic (SBR). When natural was substituted for SBR in either the tread or carcass, resulting decrease in power loss was not as large as would be anticipated from a comparison of 100%-natural rubber tires with 100%-SBR tires. Operating temperature of a tire was found to depend on power loss and on thermal conductivity of the rubber, as well as on speed, load and the ambient temperature. ■

Noise a Problem in Spacecraft Design

WASHINGTON—Aircraft and spacecraft designers must put more effort into solving the noise problem in the future. That's what Ira H. Abbott, director of Advanced Research Programs for the National Aeronautics and Space Administration, told the Aeronautical and Space Sciences congressional committee recently.

To prove his point, Abbott blasted the legislators virtually out of their seats with a 115-decibal recording. Then Abbott told the committee that many of the big jet and rocket engines develop as much as 150 to 170 decibals. Structural members of the engines suffer when subjected to more than 140 decibels, Abbott explained. And, he said, original designs on the Project Mercury man-in-space capsule had to be revised because of noise damage.

NASA is spending some $600,000 a year to solve the noise problem. But Abbott told the committee that the agency hasn't been very successful so far. ■

8-ton Workpieces Positioned to ± 0.001 in.

This British vertical coordinate drilling machine built by James Archdale & Co Ltd, Birmingham, was designed so the worktable is floated on hydrostatic oil bearings, eliminating slideway wear, and reducing power for table positioning. Measuring system for coordinate positioning uses moirefringe techniques, enabling accurate subdividing of comparatively coarse scales. Coordinate and tool information is supplied by punched tape; tool change is automatic for up to 15 tools while spindle speeds, feeds and type of cycle (drill, spotface or tap) are preset by dial for each of the tool numbers. According to Archdale, the system is less expensive, more accurate, and has no moving parts in the optical reading head. Positioning accuracy is independent of lead screw accuracy.

Basic Research Hits $1-Billion Mark

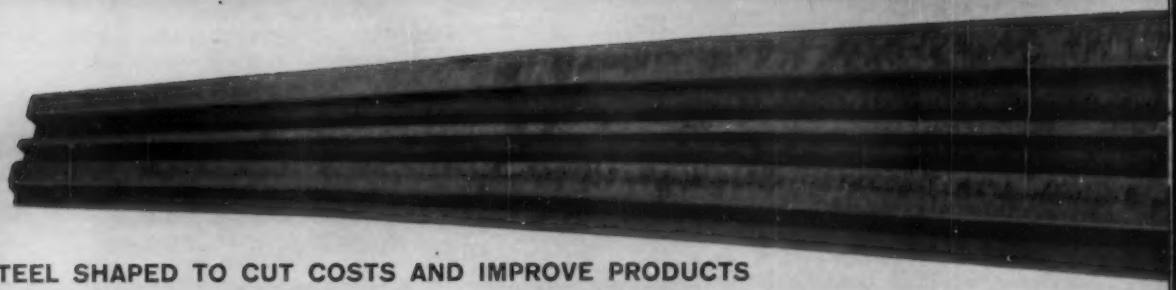
WASHINGTON—The National Science Foundation estimates that total funds for performance of basic research in the US reached a record $1 billion in 1959-60. The foundation has been studying the trend of such projects over the period from 1953-54 through 1957-58.

Its report shows that basic research increased 93%—from $423 to $835 million—between 1953-54 and 1957-58. In that same period total R & D increased at about the same rate: from $5 billion to $10 billion.

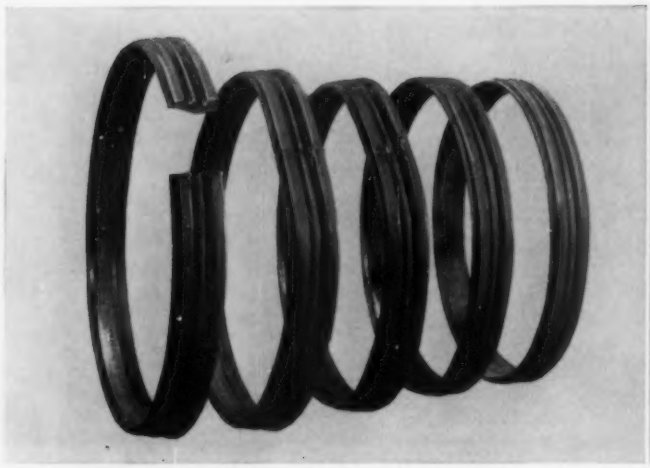
NSF finds that salaries of engineers and scientists constitute the largest cost item in basic research even though costs of equipment have risen during the surveyed period. Operating costs for applied research, on the other hand, increasingly include high-cost items essential to end products for missiles and guidance systems now under development.

The sharpest increase in basic research occurred in the federal government and nonprofit institutions (excluding colleges and universities), according to NSF. In both cases research growth exceeded 130%—from $47 million to $111 million in the government sector and from $26 million to $60 million for nonprofit institutions.

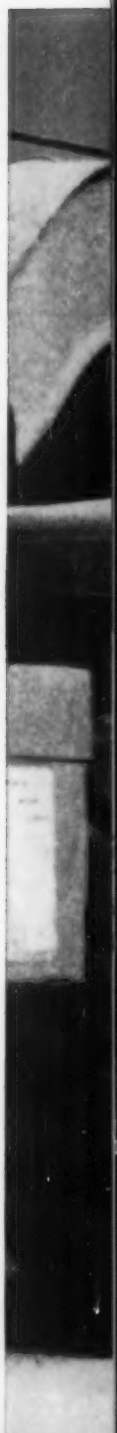
Though colleges and universities have not increased their basic research as rapidly as government and nonprofit institutions, they still handle the bulk of such projects. The educational institutions did $208 million worth of basic projects in 1953-54 and $392 million in 1957-58—an 88% gain. Industry also showed a gain, from $151 to $272 million—80%. ■



STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS



Bar becomes a ring in easy steps, 5 of which are shown here . . .
(1) circling the piece,
(2) form for welding,
(3) flash butt welded,
(4) rolled to shape,
(5) sized.



This earthmover is tougher because of steel rims made with USS Special Sections

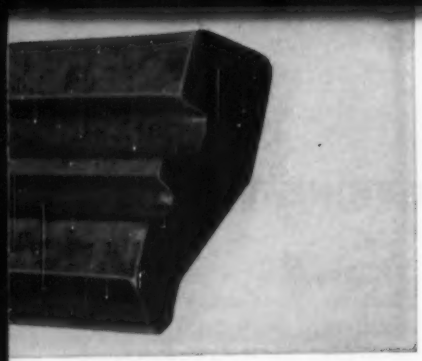
The wheel rim of this rugged earthmover is made from four special steel sections supplied by United States Steel. These are special bar shapes rolled to the approximate cross section and then formed into rings by Firestone Steel Products Company. This process eliminates many machining operations, saves steel, prevents large scrap losses and results in fast production of a superior product.

The part illustrated is the gutter section of a tubeless tire rim made by Firestone Steel Products Company. Special sections are used also because they result in straighter pieces and eliminate lateral camber. They get more uniform contact between this gutter section and the locking ring—another USS Special Section. Firestone engineers are convinced that steel is the best material they could use that would give the strength and uniformity needed for this type of rim.

Why not find out what USS Special Sections can do for you? Write for our free booklet illustrating the many intricate shapes already being produced. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company
United States Steel



...because it's tougher
...because it's stronger

OVERSEAS REPORT: NEWEST SWISS MACHINE TOOLS BID

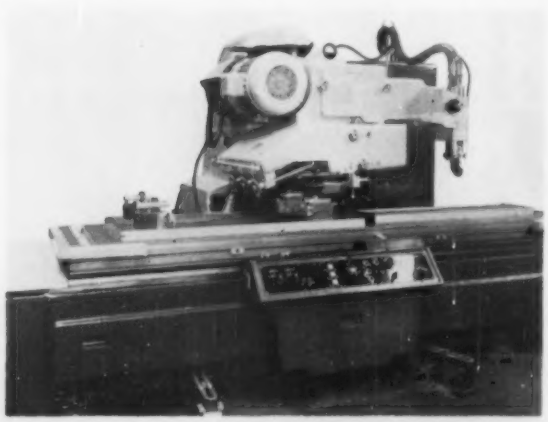
ZURICH—The annual Swiss Industries Fair here was dominated by the nation's machine-tool industry, which participates every other year. Stealing a lead on the National Machine-tool Builders Association exhibit in Chicago, Sep 6-16, the Swiss emphasized automation of manufacturing processes in the precision field for small and very small parts. It's reported that the Chicago exhibit will place part of its emphasis on this field.

Of the 2300 Zurich exhibitors (200 more than 1959), over 100 were machine-tool manufacturers—and were all Swiss because the Fair is not open to foreign products. Though many consider this limitation severely handicaps attendance, as compared with Hannover—the German show generally is rated as Europe's No 1 Fair (*PE*—*May 30, p 15*)—the number of foreign visitors attending the Swiss Fair increased by 20% to 10,000. Total visitors topped 300,000.

—Raymond Shah,
McGraw-Hill World News

PRECISION COORDINATE SPARK-EROSION MACHINE combines optical jig borer and AGIE precision sparking workhead. The jig borer, by Societe Genevoise d'Instruments de Physique (SIP) of Geneva, incorporates built-in standard scales; readings to 1 micron can be made on micrometer dials of the projection screen. Industrial Electronics Ltd (AGIE) of Losone-Locarno, Switzerland, says maximum stock removal is 0.02 cu in./min., roughness of machined surface varies between 40 and 60 microns.

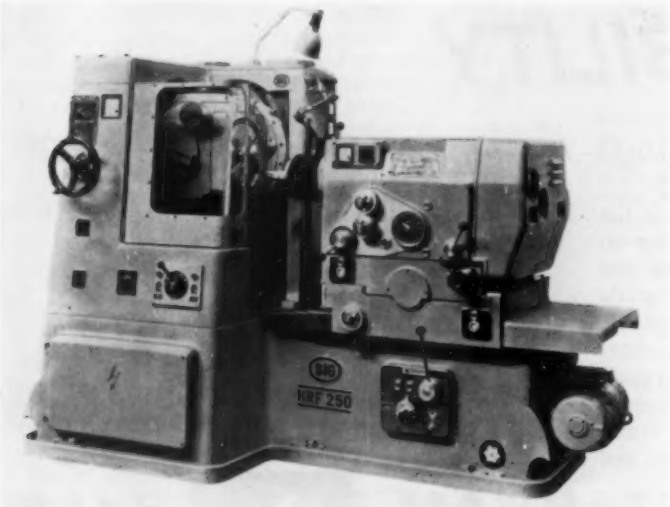
MULTISPINDLE DRILLER, BORER, TAPPER is specially designed for finish-machining precision parts such as watch plates. Designed by Henri Hauser SA of Bienne, unit has electric monitor which switches off machine if any one of the 20 spindles fail. A signal light indicates defective unit.



TURBINE-BLADE MILLING MACHINE is advanced development of hydrocopying unit by Starrfrasmashinen AG of Rorschacherberg. New unit has 3-spindle milling head inclined at 20°, vertical and transverse hydrocopying devices, longitudinal and transverse pickfeed, electrical copy stroke limiting and membrane feeler heads; 60-in. turbine blades are producible with accuracies of 0.0012 to 0.002 in. Hydraulic-electric control equipment is housed in separate cabinet.

FOR SMALL-PARTS CUSTOMERS

PRODUCTION JIG BORER with automatic coordinate positioning is manufactured by Oerlikon Machine Tool Co (Buehrle & Co), Zurich. Electronic control, by Contraves AG of Zurich, automatically positions quillhead and table. Program data is supplied by decade switches or punched paper tape using a 5-unit code. Coordinate locations are recorded as decimals, using a teletypewriter keyboard. Letters on keyboard program other machine functions.



CAM MILLING MACHINE has work headstock that can be swivelled through 90°. Designed by Schweizerische Industrie Gesellschaft (SIG) of Neuhausen Rhine Falls, the rotating headstock enables disk and cylindrical cams to be machined without auxiliary equipment. Unit is specifically designed to meet needs of small-lot manufacturers.

Japanese Auto Firm Expands R & D Programs

TOKYO—Toyota Motor Co has disclosed a plan to build a research lab in Nagoya, Japan. It is being jointly financed by 10 Toyota divisions to promote their technical-innovation programs. Research projects for the $4.2-million lab will range over a variety of technical problems including materials, mechanical engineering, engineering physics, electrical engineering, chemistry and chemical engineering.

Meanwhile, Toyota has announced that its auto production is steadily increasing. During July the company turned out 13,000 vehicles. ■

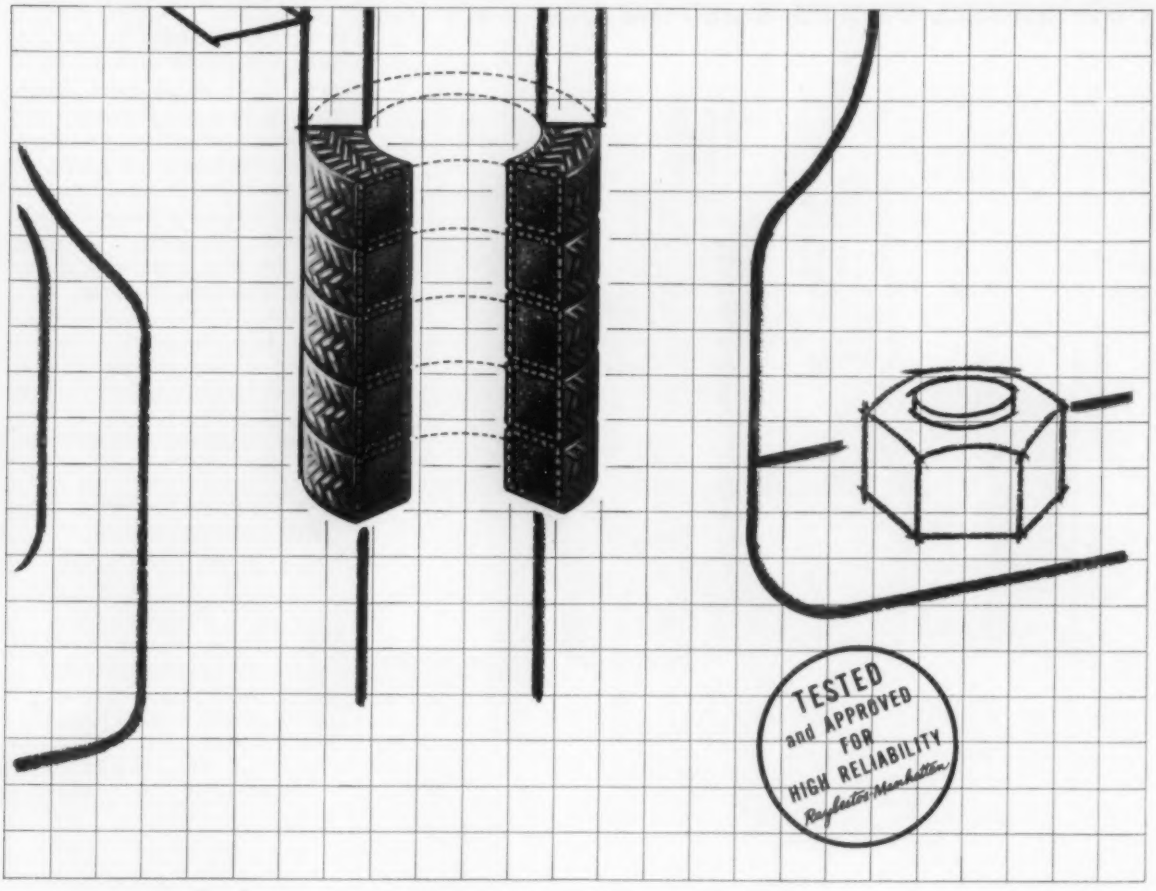
European-Engineers Report Available

NEW YORK—The European engineer is in some respects like us, in others very different. What does he think about the present situation? More importantly, what is he doing about it? The Common Market, the Outer Market, new ideas and techiques, and all the other questions.

More important still is the effect of all of this on you and your job. The Common Market is creating competition in our backyard, competition favored by lower labor cost, higher invention rates per capita and more rapidly increasing productivity.

PRODUCT ENGINEERING'S editor asked your questions about all this in a six-week, six-country tour, during which he interviewed almost 100 men in 50 organizations. The answers—man by man as well as in summary—are in a detailed report published in the August 29 issue. Reprints of this 24-page special report are now available at $1 each. Send your order with remittance to Reader Service Dept. Product Engineering, 330 W 42nd St, New York 36.

Designers think of R/M first for asbestos, rubber,



R/M CAPABILITY

develops valve stem packings for temperatures above 1000°F

A good example of R/M capability at work is the development of valve stem packings for service on lines handling superheated steam, hot gases and oils. R/M No. 325—made by braiding AAA grade Inconel wire inserted asbestos yarns over a plastic core—is typical. The core contains pure, long-fiber asbestos, graphite and other ingredients. All organic materials which tend to carbonize and become a solid mass at high temperatures have been eliminated. This reduces volume loss to a minimum and also reduces adjustments.

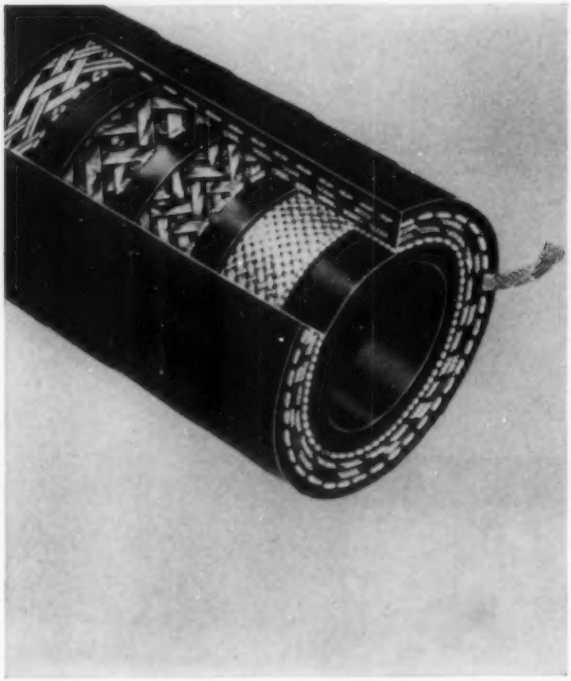
An inhibitor—compounded into the packing—combats corrosion encountered after valves are hydrostatically tested and stored. Corrosion resistors are also incorporated to help give long service life. Packings are available with and without surface graphite. Get more information about R/M High-Temperature Valve Stem Packings now.

PACKINGS

For complete information on R/M High-Temperature Valve Stem Packings, write for catalog. Packing Division, Raybestos-Manhattan, Inc., Passaic, N.J.

R/M

sintered metal, and engineered plastic products



THE STRENGTH OF STEEL . . .

In R/M's Non-Burst BW Steam Hose

R/M offers a full line of precision-built hose for every steam application at saturated pressures to 200 lbs., 388° F. Strength and durability are employed throughout the construction of Super Master BW Steam Hose, illustrated above. Two braids of high-tensile, multiple end, non-corrosive steel wire are applied at a controlled angle over an asbestos-covered inner tube of thick steam-resistant rubber for greatest strength with minimum elongation and contraction, and provide positive protection against bursting. Cover is of special Butyl rubber to resist heat and weather. Sizes from ½ to 2 inches.

The strength of steel, the heat resistance of asbestos, the flexibility of rubber, the static dissipating wire, all in Super-Master BW Steam Hose . . . the safest high-pressure steam hose made. Write for Bulletin M630.

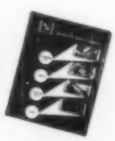
BOND FAILURES CAN BE PREVENTED!

Here's how to stop 13 of them . . .

Type of Failure	Solution
THERMOSETTING ADHESIVES	
• Cohesive failure	Check film with solvent used in adhesive. If solvent softens the adhesive film or becomes tacky, this indicates insufficient cure. Make sure bond line time and temperature is used.
• Adhesive failure from metal	If metal surface has a white, clean appearance, check cleaning technique.
• Adhesive failure from substrate other than metal	Try prime coat of diluted adhesive, also check compatibility.
• Cellular areas in adhesive line	Increase pressure and/or adhesive.
CONTACT ADHESIVES —room temperature setting	
• Tacky film	If film should dry hard but remains tacky, the cause may be entrapped solvent or migration of plasticizer from one substrate.
• Shiny areas	Poor contact, insufficient pressure or insufficient amount of cement.
• No bond	If heat reactivated type, adhesive was too cool at time of assembly or poor compatibility.
• Failure in adhesive from metal	Improper cleaning.
• From substrate other than metal	Incompatible or unclean surfaces.
HOT MELT	
• No bond	Incompatibility, adhesive too cool at time of assembly. Parts too cool at time of application of adhesive.
EPOXY BASE ADHESIVES AND CASTING COMPOUNDS	
• High exotherm	Mix lower volume and pour mixed material into shallow tray. Cool base and activator before mixing or use Metermixing equipment.
• Tacky film or casting	Improper base activator ratio, improper mixing of base and activator, improper cure. Check bond line temperature.
• Flexible casting or film of rigid adhesive or casting compound	Improper mixing of base and activator, improper base and activator, improper cure. Check bond line temperature.

Bond failures can be prevented! Raybestos-Manhattan's adhesive experts also have solutions to less common causes of bond failures . . . based on more than 20 years' experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. Why not call on them today for the answers to your adhesive problems—no cost or obligation, naturally.

RUBBER



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ADHESIVES

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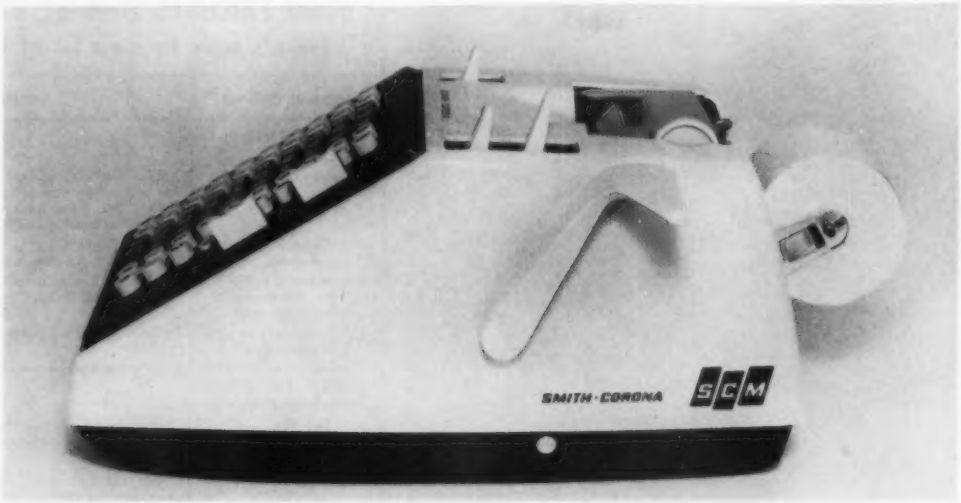
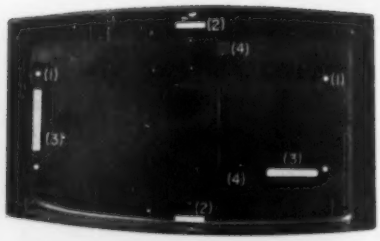
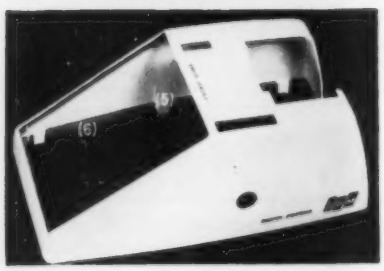
R M

CIRCLE 204 ON READER SERVICE CARD

CIRCLE 23 ON READER SERVICE CARD







Machine base (above) is injection-molded of an acrylonitrile-butadiene-styrene copolymer. Screw holes (1) molded into base eliminate drill jigs and also serve to locate machine in assembly. Stamped-metal detents, assembled into recesses (2) molded into sides, permit releasing machine from base by depressing two buttons on exterior of housing. Rectangular openings (3) are also molded in: top one makes serial number visible from outside of machine, bottom rectangle is for fastening machine to cashbox. Molded-in stabilizers (4) keep machine from shifting out of position on base.

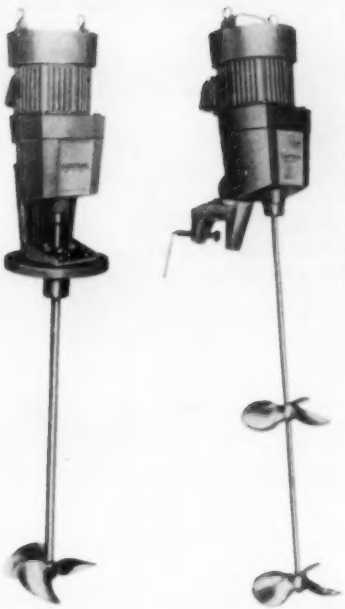
Machine housing is injection-molded of high-impact polystyrene. Beveled bosses (5) locate and latch housing to machine and base. Polyurethane (6), cemented to case interior cushions points at which base, housing and faceplate meet, and also deadens sound. Machining of side holes for handle, and hot-stamping of name and trademark were done by the molders, Auburn Plastics Inc.

Smith Corona-Marchant Inc has introduced an adding machine that has more applications of plastics than any other product of this type. Virtually all parts—aside from the operating mechanism itself—are made of this material. Compared with former model (at left, above) over-all production costs are reportedly 64% lower. Also there is an estimated saving of $11,500 for retooling and tool-maintenance. The poor fit between the former model's metal base and top was corrected, and several painting and finishing operations were eliminated. Even inventory problems have been eased because only the faceplace or keyboard must be changed to adapt the housing system to models available.

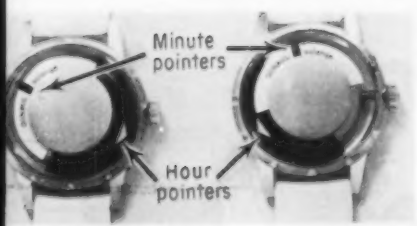
The older model's classic roller-knob handle was replaced by a one-piece Delrin molding sculptured to fit the fingers throughout the pulling action. Function keys were reshaped to provide more accurate and comfortable finger positioning. Error-correction keys were color-coded red to aid identity. A choice of colors was provided by molding housing in off-white, grey and beige, with all other parts in a neutral color that harmonizes with any of these basic shades.

Rubber feet are traditional on office machines, but in this adding machine they have been replaced by thin strips of rubber, stapled to the plastic base. This gives a lower line and is said to reduce machine creep as well.

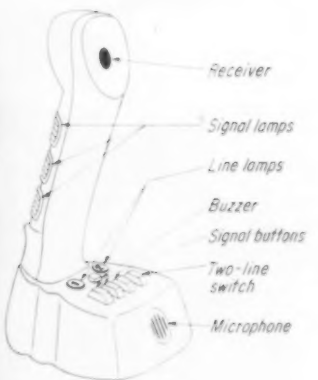
The new line comprises five 10-key, manually operated machines, two of which can also subtract. The same machine is also used in combination with a cashbox in a companion line of cash registers. Designed by: Smith-Corona-Marchant Industrial Design Dept—Karl Kober and Robert Vranken; S-C-M Engineering Dept—E. G. Moshier, C. H. Kennedy, D. C. Metzgar, R. C. Pappas; Stevens-Chase design associates—D. O. Chase, P. H. Stevens, B. R. Stewart.



Propeller-type mixers come in either portable or fixed models for fluid agitation in the process industries; achieve an integrated look because end-bell (housing fan) complements lines of upper section of gear case, which also serves as lower end-bell for motor in its finned housing. Chuck has been redesigned to provide two-hand operation: mixer shaft is inserted as far as it will go and secured with hex wrench. Portable model has position-indexing device on clamp socket that permits adjustment of mixer so propeller can be positioned for best flow and agitation. Made in sizes ranging from 1/8 to 3 hp, by Mixing Equipment Co Inc, Rochester, NY.



Just how stark and severe watch design can get is demonstrated by dial-less wrist watch, whose face is comprised primarily of rotary dark and light segments on which are marked hour and minute pointers. Rim of case carries unnumbered triangular markings indicating positions of hours, but these are so restrained that this timepiece may prove little more than a time-estimating device. Designed by Consul Watch Factory, La Chaux-de-Fonde, Switzerland.



Though light and small, this intercom combines receiver, microphone, signal lamps, buttons, line switch, buzzer and all other elements usually found in the traditional, relatively bulky desktop intercom box. Besides giving customary interoffice communication, the Swedish-designed unit can be used for: conference calls; registering fire and burglar alarm signals; recording (with an attachment) incoming calls; calling frequently used numbers by pushbutton; dictating (in conjunction with central dictation-equipment installation). The device is also completely portable, since it is designed for plug-in connection to any suitable wall jack. Weighs 17 oz and is about 10 in. high. Normal desk position (receiver turned away from user) puts signal lights within same range of vision normally needed for paperwork; this allows monitoring incoming calls without need to lift or turn one's head toward a call box on wall or another part of desk. Manufactured by Tjeders Industri Akteinbolag, Malmkoping, Sweden.

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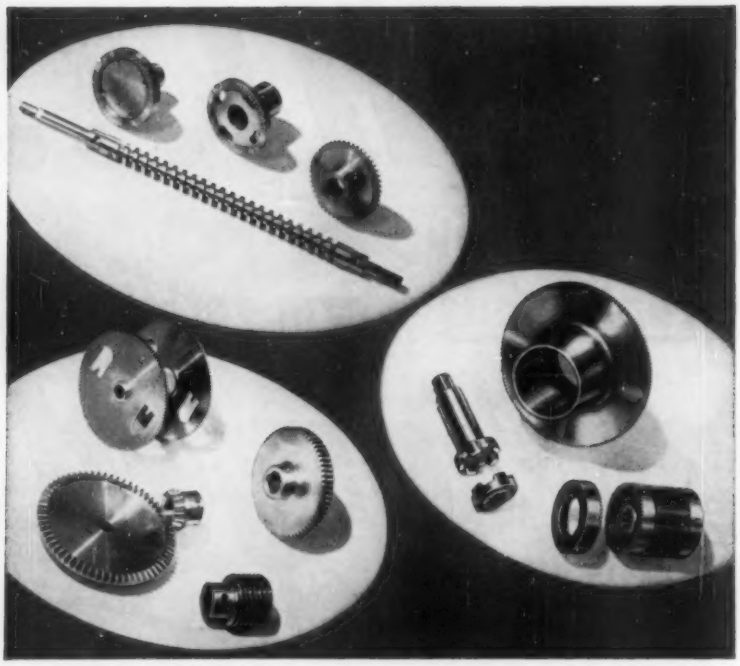

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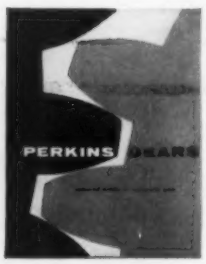

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READER TO EDITOR

Creative Engineers and Education

To the Editor:

In your July 18 issue, p 24, Ray Borst has much to say about education for creative engineers. I can certainly agree with him that such education must be broad, for a new approach to a problem can often be found in seemingly unrelated arts. However, let's not radically revise our educational system to suit the creative talent. What Borst fails to state is that very few of us are endowed with the creative ability, and if he himself does have it, he is blessed among men. However we might revise the curriculum, we would soon find that most of the "impatient, the enthusiastic, the ambitious individuals" were still dissatisfied. Further, they will do just what Borst is doing; they will go ahead and find the education that they want.

It is not easy for management, universities, or anyone else to fully satisfy the cravings of the gifted individual. Most of them end up in business for themselves as a result. These people are the foundation for our future well-being and we should try to do for them as much as Borst asks; but most of all, we should be thankful that we have them.

—T B Holliday
Markman Chicago Corp
Chicago

To the Editor:

I heartily agree with Ray Borst's comments in "Points of View." I am one of those dreamers though I am no longer young. Some of my dreams included the automobile stoplight, the automatic transmission, a circular-cutter die-head, the gas turbine, the thermoelectric generator, and the solar generator, to name but a few.

Unfortunately I had to leave school after the sixth grade. Later, in night school studying physics and chemistry, my mind would leap ahead to possibilities that have since been accomplished. When I see in Product Engineering the notice of something new which I had conceived years ago, I get as much a thrill as though I had brought something to being myself. One of the developments I am looking forward to is the conversion of atomic radiation into electric current.

—John G McCargar
Los Angeles

To the Editor:

Your article in the July 18 issue was extremely pertinent to the art of engineering today. Unfortunately, it will be dismissed as the outburst of an immature, emotional young man, smiled about and forgotten. That it happens to be true is beside the point.

The large corporations are not interested in creative personnel. Such people have too much imagination to suffer through the long apprenticeship of routine engineering assignments and thus gain the seniority which would permit them an extremely limited freedom for individual work on their own. Much safer is the man who is easy for everyone to get along with,

who is in the habit of adding 2 plus 2 and not putting down 2 squared, who is not late to work and who will not under any circumstances let his interest stray beyond the responsibility of his own particular chore. —CHARLES S MILLER
Brooklyn, NY

Aids for Patent Searchers

To the Editor:

The article, "Patent Subclasses—a Rich Vein of Free Ideas," (June 6, p 83) was excellent. The establishment of Branch Public Patent-search Rooms will be a great aid to inventors and product designers. All engineers and inventors should actively encourage and expedite this program. —EDWARD H ARNOLD JR
New Orleans

Do It Right—the First Time

To the Editor:

Your editorial "Simple?" (Aug 1, p 29) is as welcome a note to the industrial designer as the engineer. Admittedly, a simpler product requires a higher per-unit initial development cost; but the basic concept of simplicity yields very respectable advantages in production, operation, and even selling. Today's relationship of man to machine is complex enough. We have devoted considerable time to reducing appearance and human engineering to fundamental requirements on each of our projects. These requirements form basic criteria for design, and must be fulfilled. Our profession, as an element in technical-product development, must tend toward practical simplification—in good taste, not ornamentation.

As one of my clients pointed out, "Many firms never have time to do the job right the first time, but always have time to do it over again." His feelings and mine are emphatically for the opposite position, a meticulous, step-by-step development toward a simple, well-thought-out product. In taking time to do the job right the first time, we consistently arrived at better solutions in the final analysis. I hope more industrial designers will heed your advice —more common sense and less frills.
—CHARLES M HUCK
Design Analysts NYC

COMING EVENTS

SEPTEMBER

6-16 . . . . National Machine Tool Builders Association, Production Engineering Show, International Amphitheater, Chicago.

7-9 . . . . American Society of Mechanical Engineers jointly with AiChE, AIEE, IRE, and ISA; Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass.

26-28 . . . . Standards Engineers Society, 9th Annual Meeting, Hilton Hotel, Pittsburgh.

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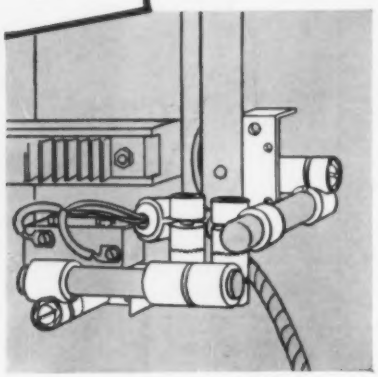

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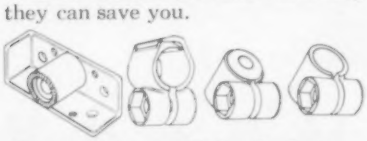

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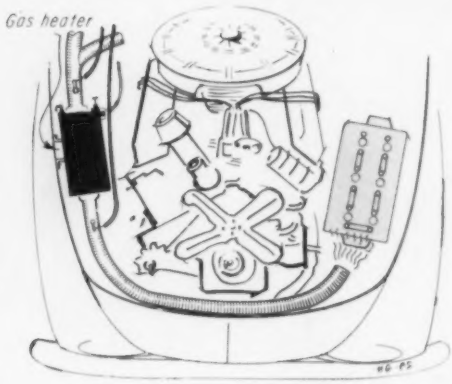
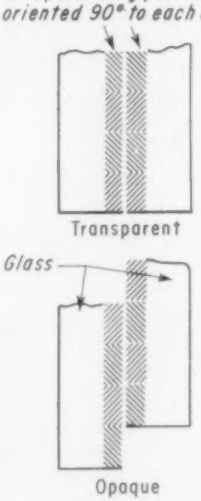
WHY DON'T THEY R&D..?



. . . a heater for automobile storage batteries. Three effects combine to make an automobile engine difficult to start on a cold morning: the oil is thick and sluggish, the fuel cannot vaporize properly, and the battery cannot deliver full power. When the temperature drops from 80 to 0 F, it is estimated that the power required to turn over the engine jumps 2½ times, while the power available from the battery drops to one-third. One answer would be to combine an electric battery heater with the electric crankcase heaters now common in many northern climates. Heater, perhaps, would be a powdered chemical that could be dropped into the battery to heat it by chemical action. Such a chemical should not, of course, interfere with the normal action of the battery. Or how about rerouting the ducts from the gas heater so that the outlet is directed against the crankcase and battery for five or ten minutes before starting the engine? A practical solution is also of interest to the armed forces. —A Bristol

. . . controlled-transparency window glass that can be turned opaque to shut out the light. Venetian blinds are a nuisance to clean; other methods of cutting down sunlight in the daytime or providing privacy at night—shades, drapes, shutters, awnings—are either unsightly or do not allow much control over amount of light. The obvious place to put the light-control is in the glass itself; twisting a knob changes the window from transparent to opaque—or any density between.

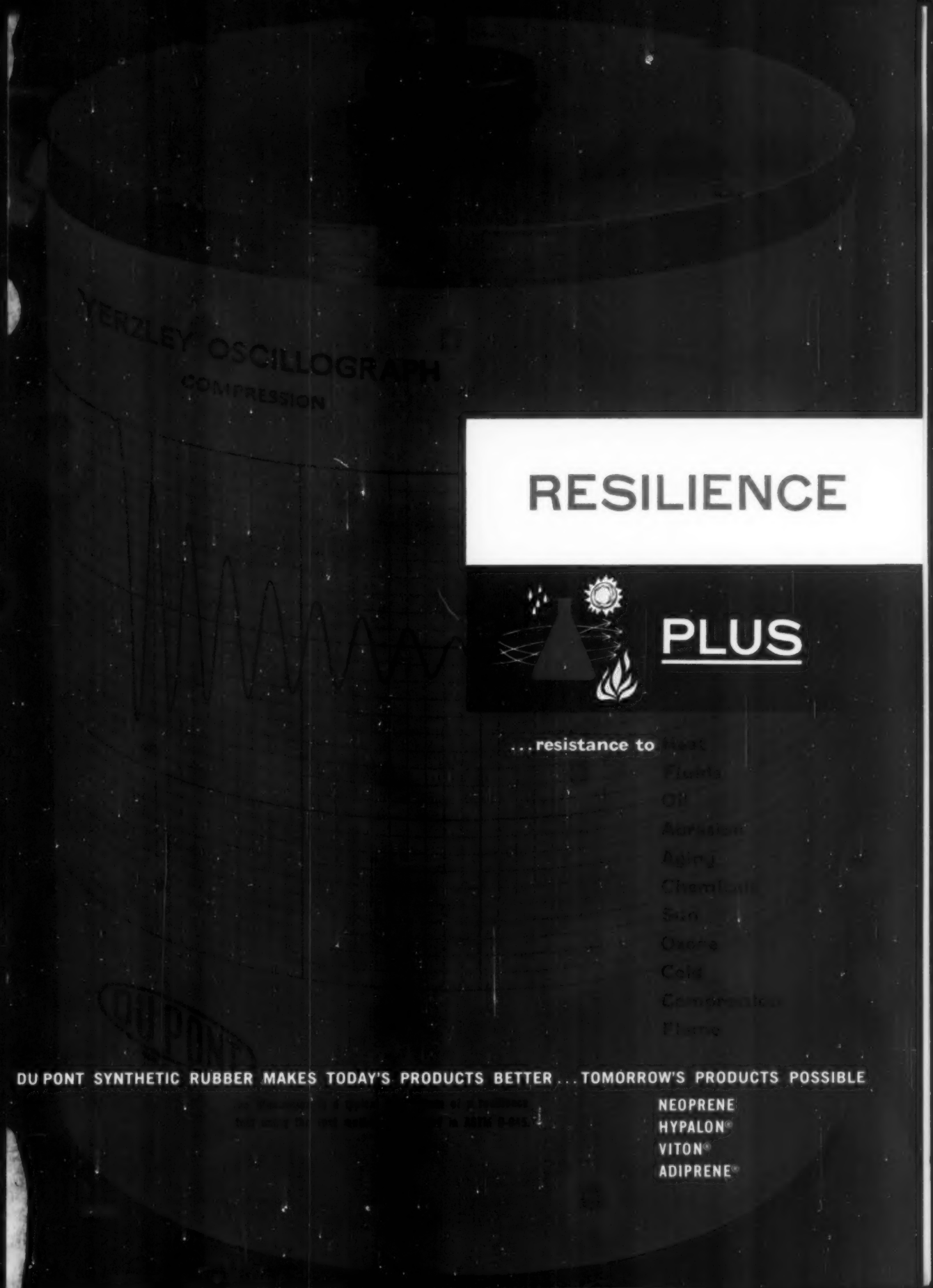
Alternating plastic strips with polarizing planes oriented 90° to each other.



One way is to make the glass in two sheets, as with laminated safety glass. Between the glass sheets are narrow strips of polarizing material, perhaps not more than 0.010 or 0.020 in. wide (see sketch). When strips polarized in the same direction are aligned, the glass is transparent. When the sheets are shifted the width of one strip, the glass turns opaque. Between these two positions are varying degrees of semitransparency in which the glass would probably seem to have a slightly striped appearance (depending on width of polaroid strips).

Two other possibilities: One is the Kerr cell (Jan 13 '58, p 5) which has been used as a high-speed camera shutter. It has an opaque fluid trapped between two glass surfaces. When a pulse of high-voltage energy is applied the fluid turns transparent. Or perhaps the window could be made of birefringent material and supported between barium titanate transducers in the manner of the shutter described in this issue, p 6. Controlled-transparency glass might also be used for automobiles, trains, aircraft, etc. —P F Ransom

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.



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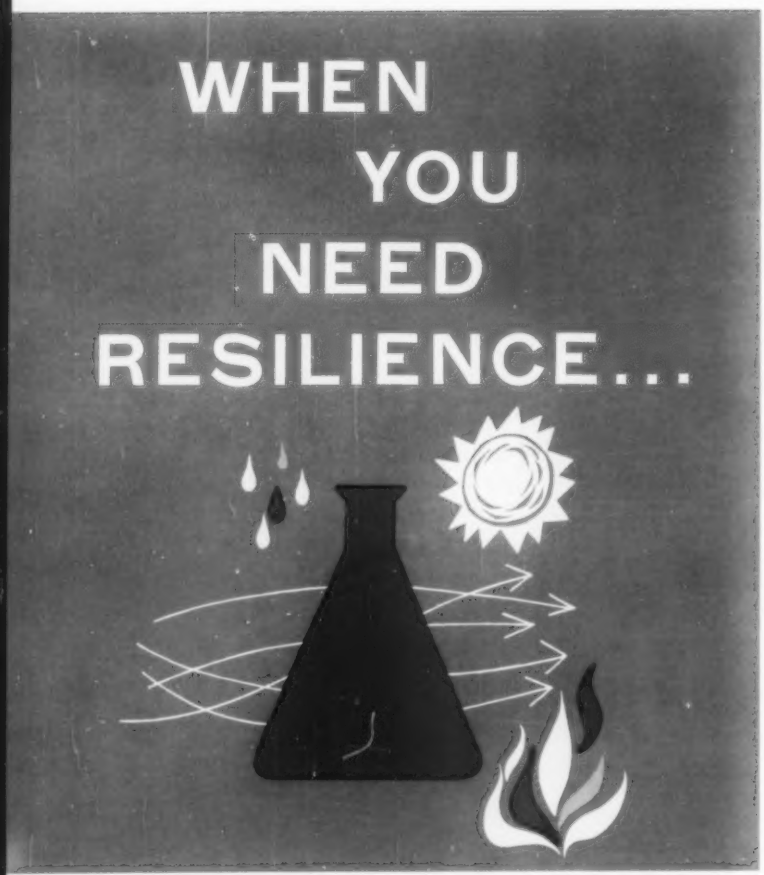

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Coiled heater cord for small appliances is jacketed with neoprene for long-term flexibility, resistance to heat, food chemicals and cooking oils. A test cord underwent 500,000 flexing cycles without damage.

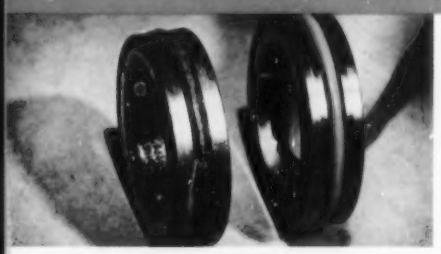
Inflatable dam made from tube of neoprene-coated nylon is used in Los Angeles to divert river water for conservation. Test material withstood weather, sun, abrasion from river debris for two years.

New air valve design for ventilation units is a helical spring covered with neoprene tubing. Neoprene tubing is expected to last as long as the ventilation system and still maintain a tight seal on the close-off.

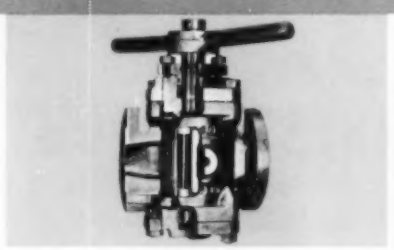
House-size tarpaulin is used by fumigators to keep exterminating gases from escaping. It is made of nylon fabric coated with Du Pont Hypalon . . . resists sun, weather, fumigating gases . . . is easy to handle.

Cathedral roof with sprayed-on coating of Hypalon stays gleaming white in spite of tropical sun, wind, rain and salt spray. Weathering has not caused the reflective roof coating to dull or deteriorate since 1957.

Hypalon shows outstanding resistance to strong oxidizing chemicals. This tubing was used to pump chlorine bleach (5¼% hypochlorite) at 158° F. . . . was still good after a week. Other rubbers failed in 24 hours.

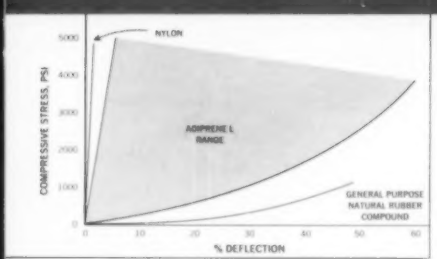


Viton O-rings seal bearings in heat exchanger at 525° F. . . . outlast other synthetic rubbers 25 to 1. They resist fatty acids, dibasic acid, phthalic acid, solvent and petroleum products . . . maintain their resilience.

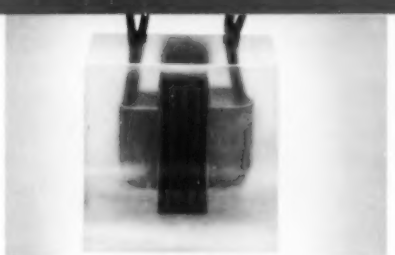


This refinery valve has been used in a benzene line for over a year. Its O-rings and valve seat —made from Viton—are still assuring positive shut-off. Viton parts also resist toluene, xylene, 380° F. alkylate gas, 400° F. propane.

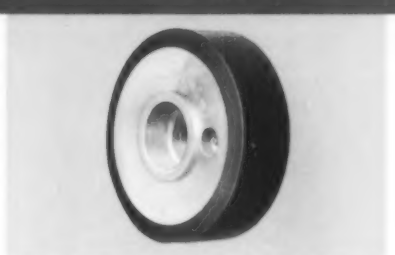
Fire seals in the wings of the new B-58 "Hustler" are made from Viton-coated asbestos fabric . . . resist heat, ozone, jet fuels, fumes and corona . . . are equivalent to stainless steel in fireproofing qualities.



Load-bearing capacity of hard Adiprene L compounds ranges between that of general purpose rubber and the harder plastics. You might use Adiprene L compounds to replace non-elastomeric materials where cushioning or damping properties are needed.



Adiprene L can be used alone or in combination with epoxy resins for potting and encapsulating electrical assemblies. Its flexibility helps protect delicate instruments from damage. It has excellent resistance to thermal shock.



Industrial wheels made of Adiprene L outlast rubber and plastic . . . are outstanding in abrasion resistance. They resist oils, mild acids and alkalies, temperature extremes, weathering and aging . . . are resilient and non-marring.

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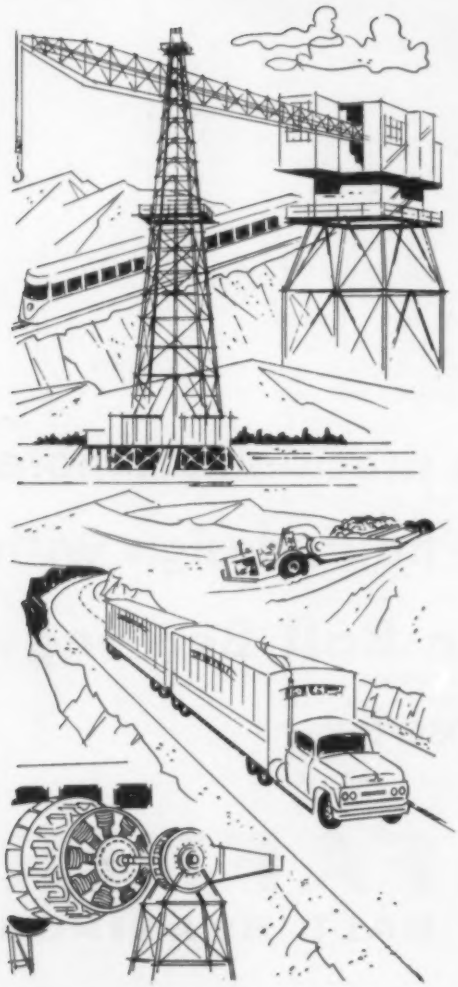

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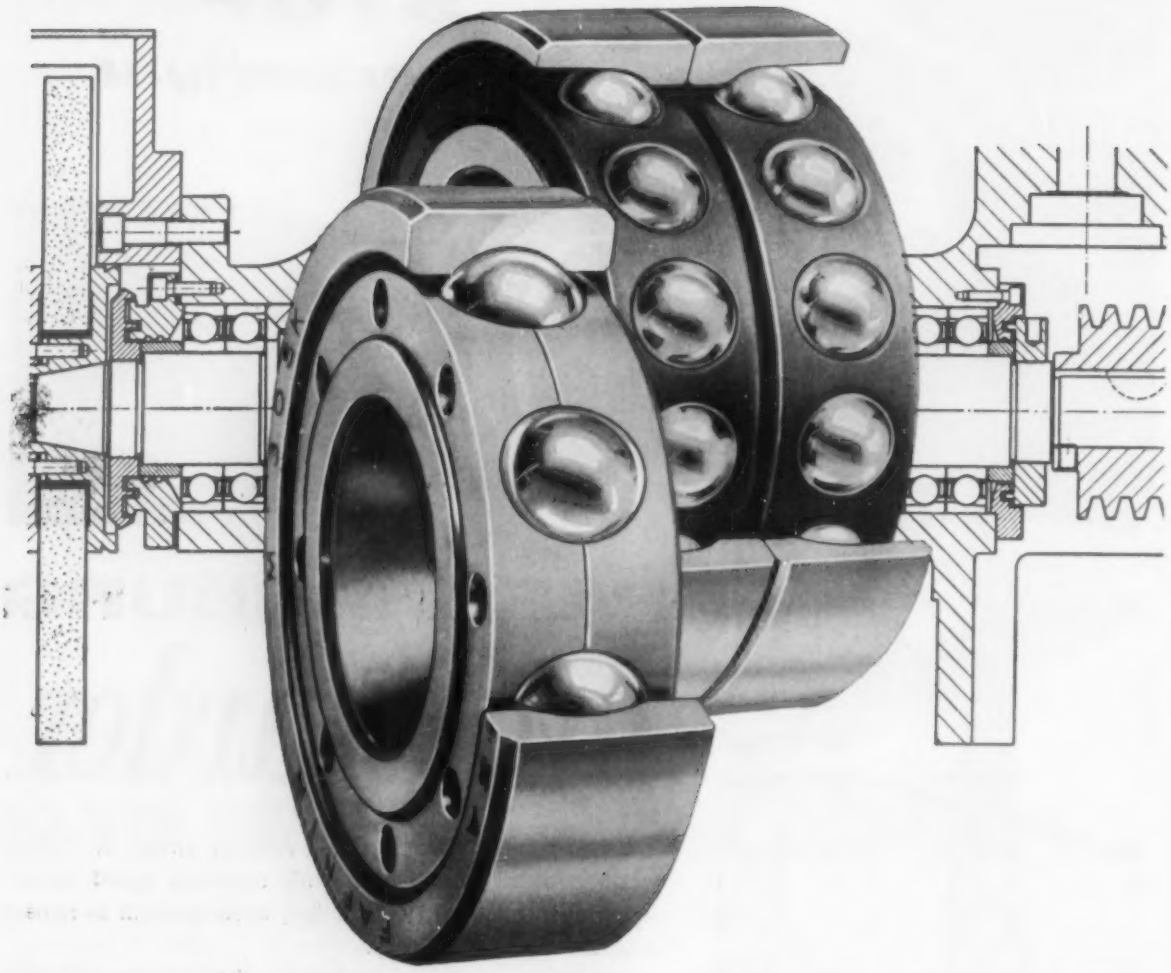

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THREE STEPS to PROFESSIONALISM

At a Brown University commencement 48 years ago, Louis D. Brandeis gave these three characteristics which distinguish a profession:

1. A profession is an occupation for which the necessary preliminary training is intellectual in character, involving knowledge and to some extent learning, as distinguished from mere skill.

2. It is an occupation which is pursued largely for others and not merely for one's self.

3. It is an occupation in which the amount of financial return is not the accepted measure of success.

The learned judge further made the point that engineering, even at that early date, already ranked "beside law, medicine and theology" as a learned profession. His first characteristic eliminates many of the licensed "professions" (so-called), like barbering and plumbing. The third characteristic was once only too true, but seems now to be adjusting itself to some extent, and in a nation in which financial return is too often the major criterion of success.

The second characteristic is the sticky one. Engineering, particularly design engineering, can be a very impersonal thing. It can, and often does, deal with capital-goods items like production machinery, in which people are not involved, at least not visibly. And the engineer, by the nature of his work, must usually be analytical and objective rather than personal and subjective. That's his job.

It may also be his inclination. He may not be particularly interested in people, and there is nothing in much of engineering that forces him to be. There is in medicine, law and theology.

At the risk of preaching, I'm reminded of the story of three bricklayers who were approached in turn and asked what they were doing.

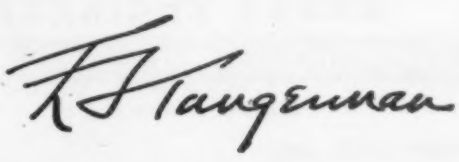
Said the first: "I'm laying bricks."

Said the second: "I'm helping to build a building."

Said the third: "I'm helping to build a church to the greater glory of God."

Even in bricklaying, there is a great deal in the point of view. There can be in engineering, too. The impersonal mechanism will have to be operated and maintained by men, and it will form part of an assembly that makes something for people. If this subjective side is considered on occasion, the job will be easier to do and better done.

And if Judge Brandeis was right, consideration for people is an essential characteristic of true professionalism—perhaps the one we engineers most commonly lack.



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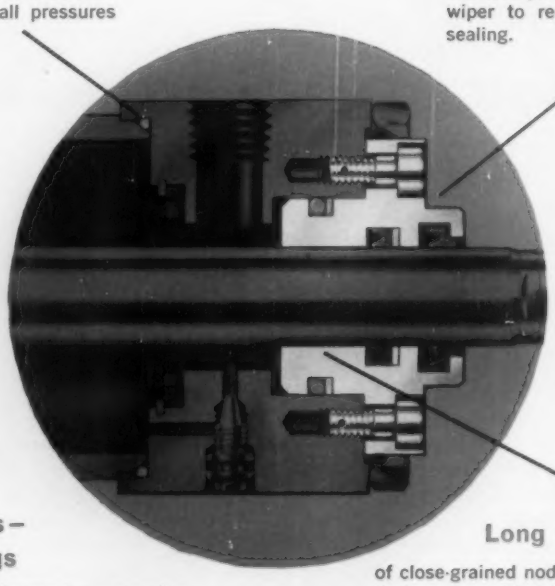

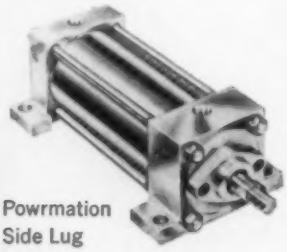

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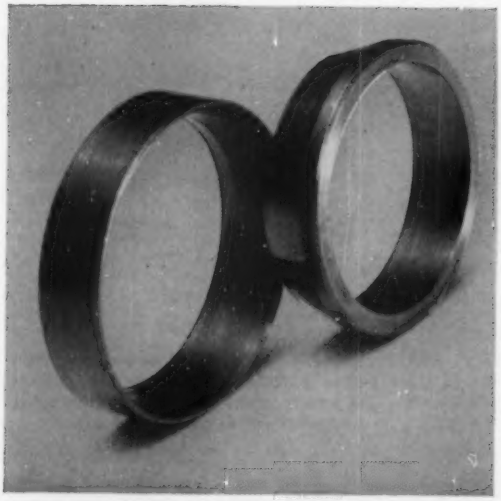

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They provide the zero clearance of a press fit and the positive drive of a shaft spline or key, yet avoid the disadvantages of precise tolerances and weakening stress concentrations.

ERIC NORD
US Automatic Corp
Amherst, Ohio

There are many ways to lock a shaft to its hub. Among them, the lesser known method of expandable bushings has advantages that often make it best choice. It offers the inherent concentricity, rigidity and torque-transmitting ability of a shrink fit plus the liberal tolerances and ease of assembly of a collet-type mounting. Yet it does not require the close tolerances of the press and shrink fits, and also does not set up the stress concentrations and notch weaknesses commonly associated with keys, pins and splines.

Two types of expandable bushings are available—solid and split. Each has its own characteristics and applications.

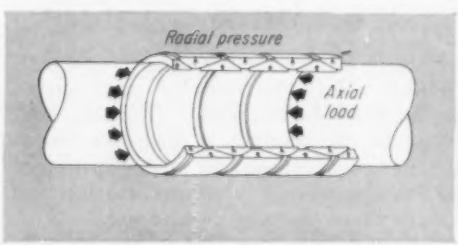
SOLID TAPERED

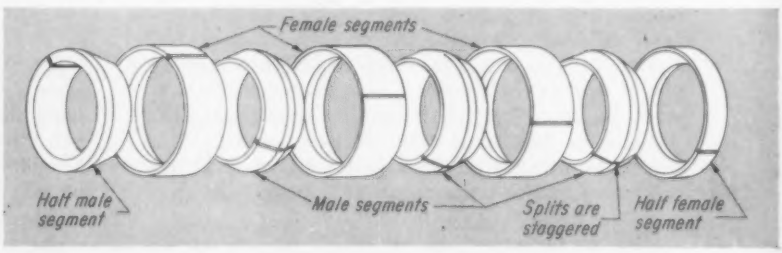
These bushings rely on elastic properties of the bushing material to translate axial force into the tightening radial pressure desired. An axial force applied to the outer ring forces it into the mating inner ring; the outer ring expands against the bore of the hub, while the inner ring contracts against the shaft.

Often more than one set of such rings is used in a connection. Here is an approximate equation that we developed for finding theoretical torque for any number of ring sets. It's derived from the action of axial force on the ring elements, neglecting minor frictional forces in the vertical surfaces.

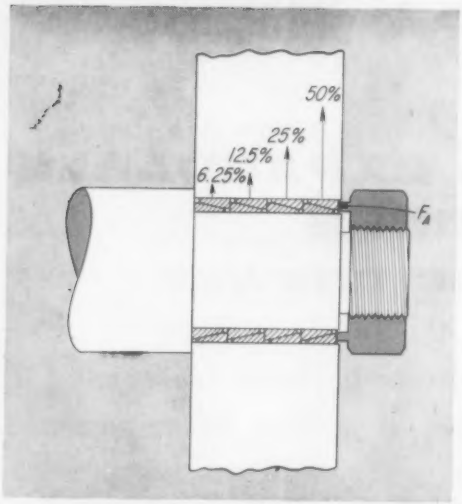
$$T_n = \frac{F_A \gamma}{2}\left[1 - \left(1 - \frac{2\mu}{\tan(\alpha + \theta) + \tan\theta}\right)^n\right]$$

Maximum torque is inversely proportional to the tangent of the ring angle; a smaller ring angle gives greater torque. But there is a limit: the ring angle must be large enough for these rings to be self-releasing for easy disassembly. An angle of 16° 40′ is a good compromise. When this angle is used with a coefficient of friction of



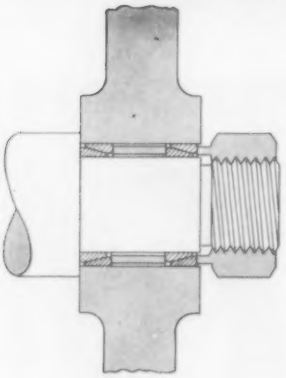


SPLIT TAPERED BUSHINGS, made by Adjustable Bushing Co, North Hollywood, Calif, transmit axial force evenly between rings and can be used for long bushings. Assembly (left) shows direction of forces. Male segments contract to grip shaft, female segments expand against hub bore. Exploded view (right) shows staggered splits in segments.



TORQUE TRANSMITTED decreases at a rate of 50% per set in mounts where hub is restrained by a shaft shoulder.

FOUR BASIC



Type 1

TYPE 1—Shaft shoulder restrains hub during tightening; ring set at left of spacer transmits only half as much torque as set at right.

SYMBOLS

- T_n — Theoretical max torque for n ring sets, in.-lb
- F_A — Axial force applied after rings are in contact with hub and shaft, lb
- r — Radius of shaft, in.
- μ — Coefficient of friction
- θ — Friction angle ($\tan \theta = \mu$)
- α — Ring angle (16° 40′ used in example)
- n — Number of ring sets
- P_1 — Radial thrust of first ring set, lb
- S_c — Compressive stress, psi
- D — Shaft diameter, in.

approximately 0.16, the torque equation shows that the first ring set will transmit approximately 50% of the theoretical torque value obtainable with an infinitely large number of ring sets:

$$T_{max} = \frac{F_A r}{2}$$

4 BASIC HUB MOUNTS

When more than one set of rings is used and the hub is restrained by a shoulder (as in diagram above), thrust force declines by 50% in each successive set when the nut is tightened. Only the first set is loaded by the full axial force. This reduction, which results when the rings grip the shaft and hub, makes it advisable to limit the number of ring sets. Type 1, above right, is a more usual design.

When the hub is not restrained by a shoulder, as in Type 2, thrust force acts from both sides when the nut is tightened. Each set transmits 50% of the theoretical maximum torque.

There are two other basic designs: Type 3, which has the same loading as Type 2, but with no axial shift of the hub; and Type 4, with same loading as Type 1, but it has four ring sets instead of two.

Our nomograph, right, based on these 4 types, gives axial load necessary to produce a given torque. For example, a 1-in. shaft that must transmit 3 hp, or 630 lb-in., requires an axial force of approximately 3000 lb in a Type 1 mounting. Types 2 and 3 would require 2400 lb; and Type 4, 1500 lb.

Radial thrust of the first outer ring against the hub is given by the equation:

$$P_1 = \frac{F_A}{\tan(\alpha + \theta) + \tan \theta}$$

For values of the ring angle and coefficient of friction given previously, this equation reduces to:

$$P_1 = 1.56\, F_A$$

This radial thrust can be used to determine the allowable compressive stress:

$$S_c = 0.477\, P_1/D^2$$

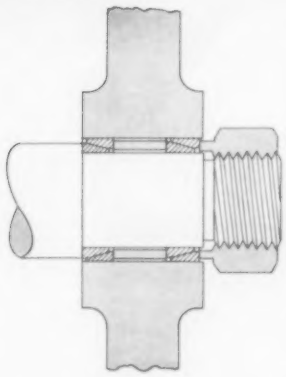
For hubs with an outside diameter double the shaft dia, contact pressures of 60% of the working stress is recommended. This working stress should then be divided by a suitable safety factor to give the allowable compressive stress. For example, a safety factor of 2 gives 8500 psi for grade 30 cast iron and 17,000 psi for SAE 1020 steel.

SPLIT TAPERED

The other version of expandable bushing is one with tapered split rings. With this type, the radial forces—acting along the axis—remain constant. They do, however, vary along the circumference, ranging from zero at the split to a maximum opposite the split. Because of the split the bushings are easy to expand and therefore can accommodate broad tolerances in hole size.

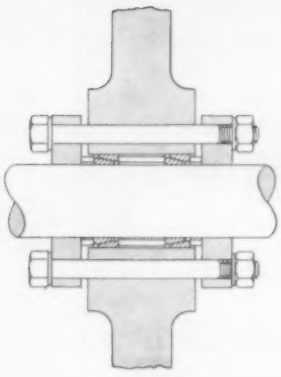
This type may be split in two, three or four places to make easier radial expansion, as well as to facilitate assembly in applications where the end of the shaft is inaccessible. Splits can be staggered, as shown on p 41.

MOUNTINGS



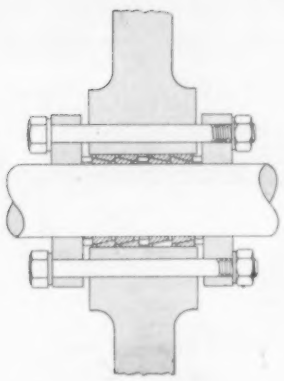
Type 2

TYPE 2—Has no shaft shoulder, so hub is free to move axially; thus loading is equal in both ring sets.



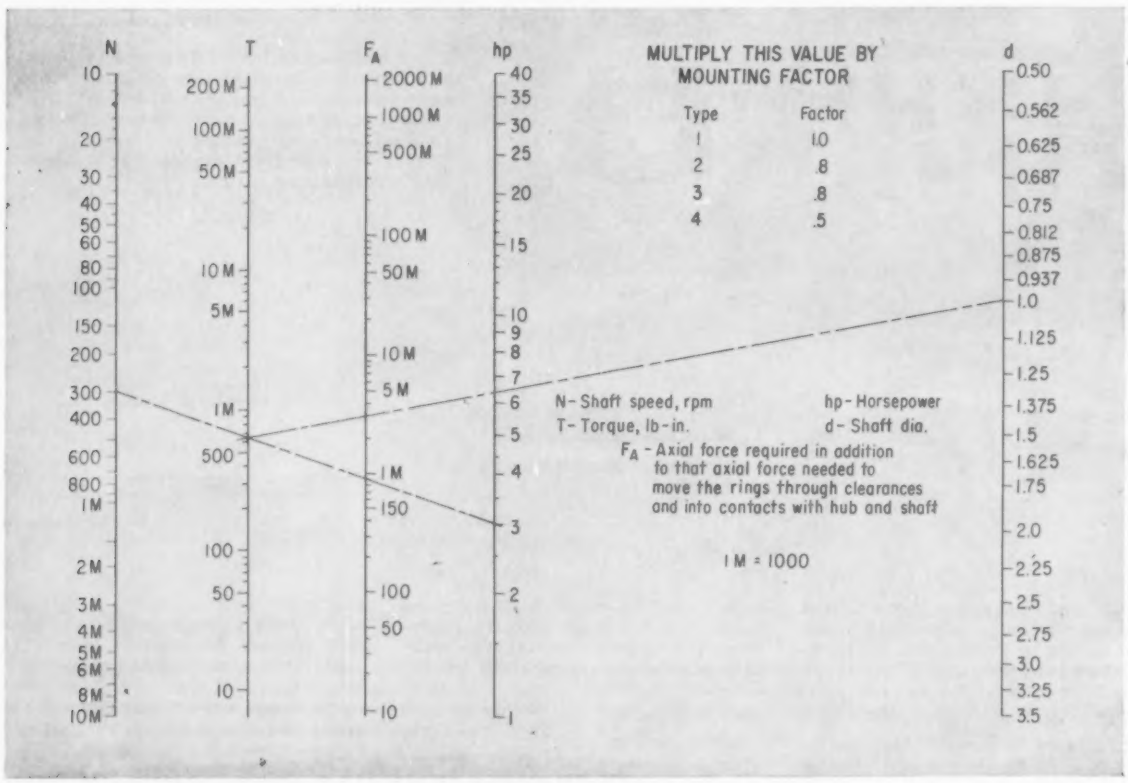
Type 3

TYPE 3—Collet-type mounting; same loading as Type 2, but hub is restrained during tightening.



Type 4

TYPE 4—Collet-type mounting; same loading as Type 1, but with four ring sets.

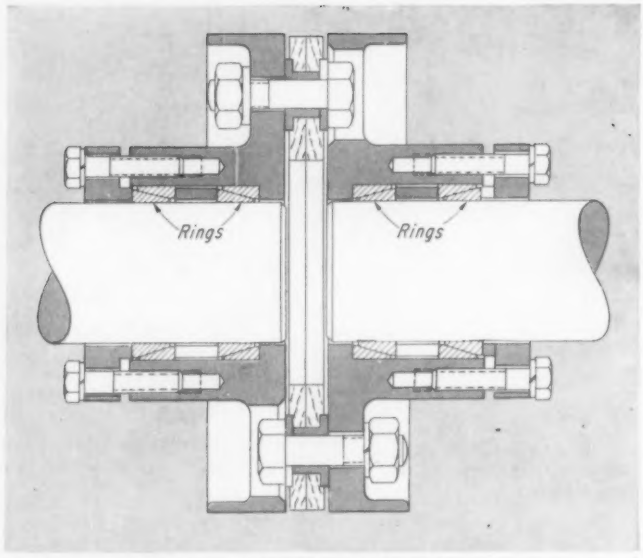


FRICTION TORQUE is translated to axial force by this nomograph.

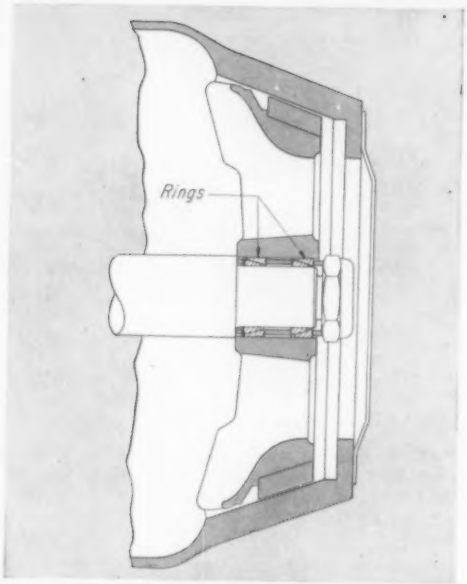
MATERIALS AND FINISHES

Expandable bushings can be made of various metal or nonmetal materials to suit particular requirements. Currently, they are made with:

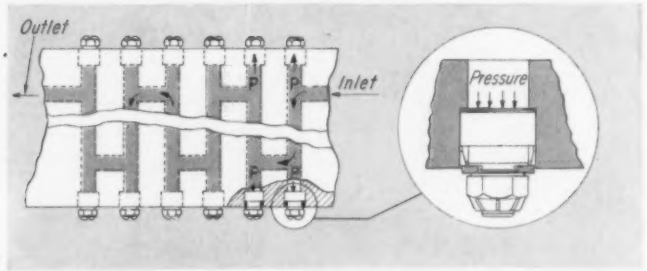
- Aluminum alloy-2024-T6, anodized per MIL-A-8625
- Sintered-bronze oil impregnated per MIL-B-5687a
- Stainless steel Type 303 passivated
- Carbon steel, B1113, cadmium-plated per QQ-P-416, Type II, Class C
- Nonmetals such as nylon and teflon—these are used as static and dynamic seals in solid tapered bushings;



A

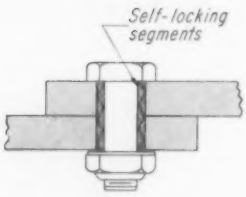


B

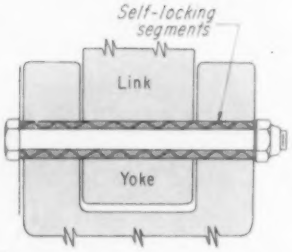


C

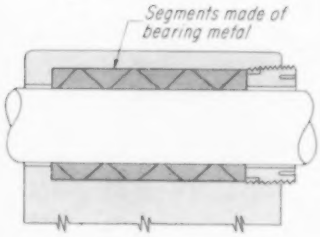
Three applications for solid tapered bushings: (A) In flexible couplings they eliminate stress concentrations and provide uniform grip; (B) In hoist brake they provide easy assembly in a compact design; (C) In plug seal they give continuous radial-pressure sealing for high-pressure steam-heating plate.



A



B



C

Three applications for split tapered bushings: (A) structural joints, which are subject to vibrations. Here the bushings provide rigidity in loose-tolerance drilled holes. (B) Link and yoke joints which require relative movement and frequent removal. The bushings give minimum backlash by adjusting the nut for proper fit. (C) In plain sleeve bearings can be periodically adjusted for wear by means of screw take-up to maintain precise fit.

stainless steel and carbon steel are also used for sealing solid tapered bushings where high temperatures as well as pressures are involved.

EDITOR'S NOTE: For additional information on related locking and fastening devices see:

We Threw Out Press Fits for Bearings, Jan 6 '58, p 67—Tests on Loctite show that ½-in. shafts can be made 0.003 in. undersize and still retain a bearing with sufficient force.

Test-results Guide High-temperature Design of Bolted Assemblies, Sep 30 '57, p 79—Recommends materials for bolts and structures for temperatures up to 1300 F.

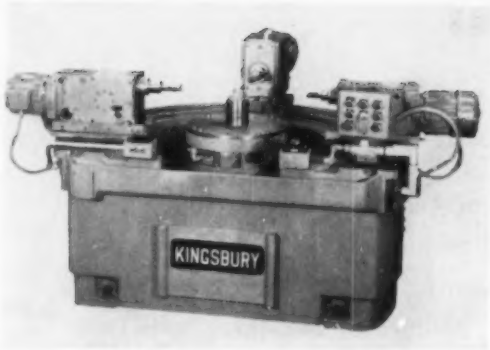
Taper Pins—17 Ways to Retain Them Positively, Nov 11 '57, p 123—Gives diagrams and descriptions of assemblies.

Assembly Methods—an Engineering Roundup, June 8 '59, p 91—Special report gives sketches and hints for a variety of assembly problems.

Insulated Screw Fasteners for Electrical Equipment, Sep '50, p 106—Shows how to use insulated screw fasteners instead of providing insulation for component parts.

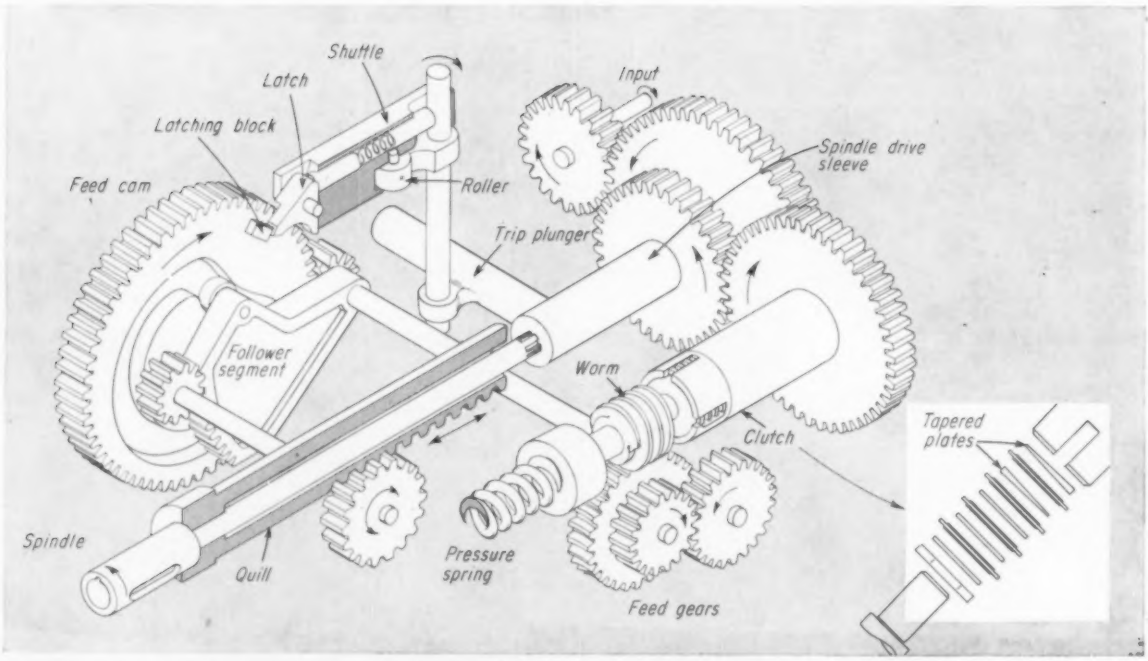
Fastening Gears to Shafts, May 30 '60, p 43—Roundup of 15 methods, with press-fit requirements and a comparative table.

The Use of Tolerance Systems, Feb '56, p 164—Complete description of the ABC system of recommended clearance.



Disengaging Drive Protects Drillhead

Double-duty worm gear allows input to run continuously even though quill drive stops completely during each cycle.



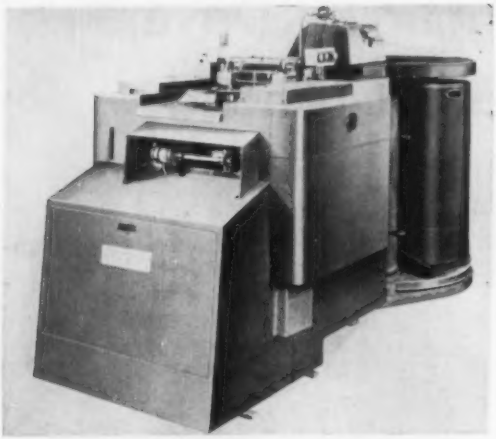
SHUTTLE LATCH AND FRICTION CLUTCH control operation of drill-head. When latching block on feed cam engages shuttle latch, this cam is brought to an abrupt halt while spindle maintains full speed. Worm gear is no longer able to rotate, so the worm "climbs" the gear, thereby compressing the pressure spring and disengaging the clutch plates. This prevents clutch from overheating.

Drive remains in this condition until plunger is tripped, starting another cycle. The shuttle roller rolls off the nose of the cam that is keyed to the shuttle shaft. The shuttle slides back, disengaging latch and latching block; this frees the feed cam and feed gears. Pressure spring now pushes worm back, thus applying pressure to clutch plates and completing connection to input. Worm then drives the feed gears, which rotate the feed cam. As cam rotates, a roller follower actuates the follower segment, which is geared to the quill. After one full revolution, the cam is stopped; the latch again engages the latching block.

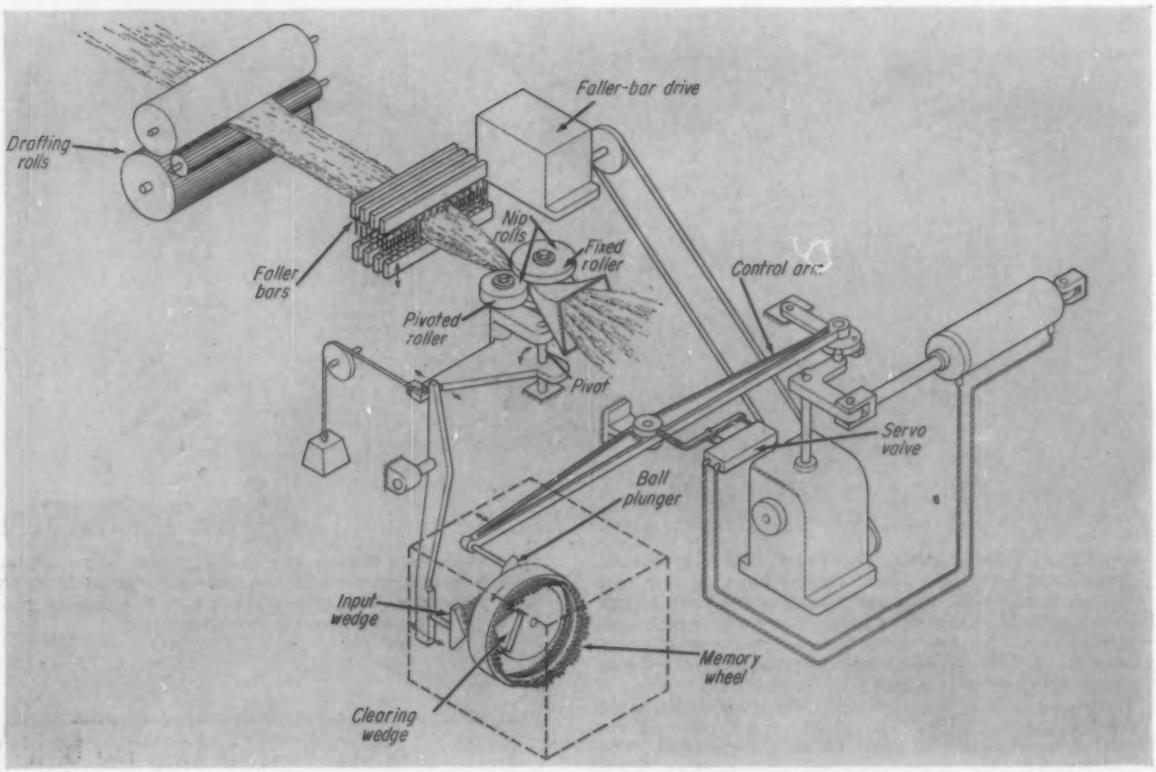
Friction clutch doubles as a safety release; any external obstacle that stops the quill has same effect as latching the cam. Two extra clutch plates are ground to a tapered profile to provide positive clutch disengagement.

PS . . . Self-contained drilling and tapping head can be mounted horizontally, vertically or at an angle. Each unit has individual speed and cam feed-control. Units can be incorporated into production equipment where a drilling operation is required or supplied with base and indexing fixture for specific operations. Drilling Unit models 4 and 16 and Tapping Unit models 5 and 17 are produced by Kingsbury Machine Tool Corp, Keene, NH.

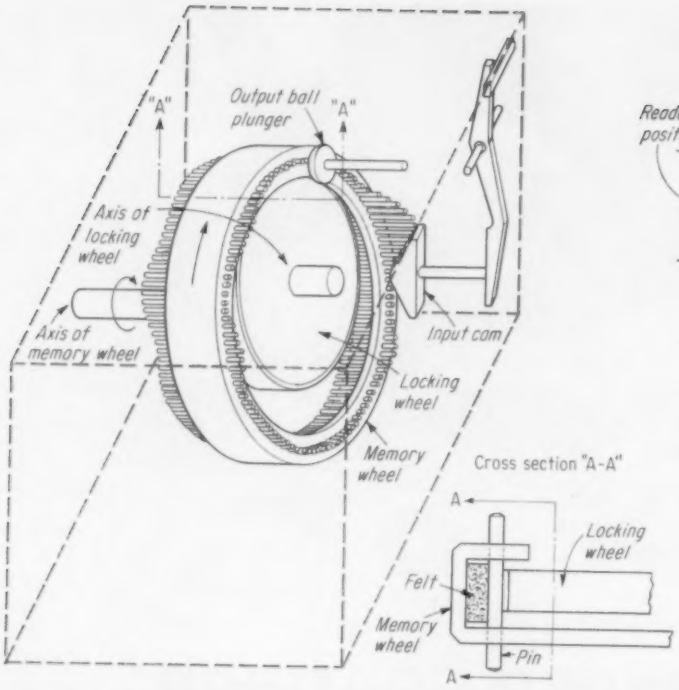
Sliding Pins Are Heart of Mechanical Memory

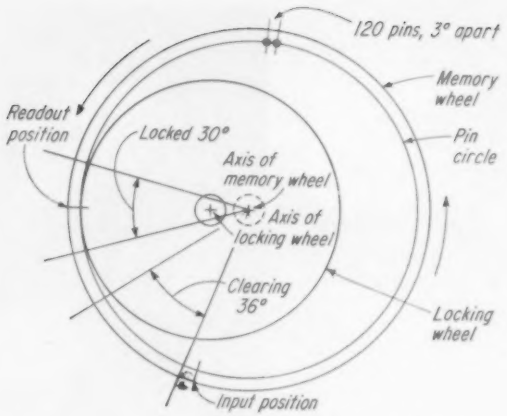


Positions of the pins on rotating memory-disk control the variable-speed transmission in this application—a textile machine. All-mechanical, the memory system offers increased reliability at reduced cost.



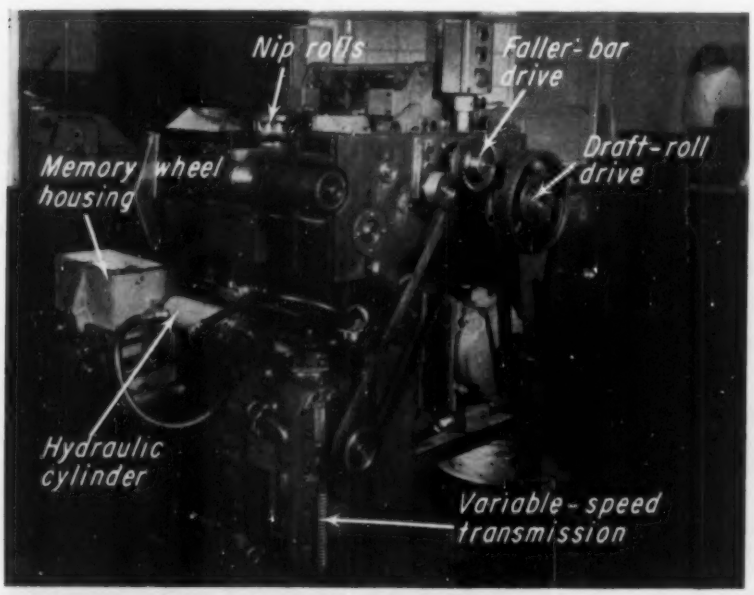
DRAFTING OPERATION starts when sliver stock is fed between a pair of nip rolls, one fixed-center, one pivoted. Stock fed to the machine is pulled through the rolls, and variations in thickness (or weight) are measured by displacement of the pivoted roll (250-lb pressure is maintained between the rollers). A series of levers transmits and amplifies movement of the roll to the memory wheel. The variations of stock weight which produce roll movement are recorded on the memory wheel and stored until the stock moves to the comb-like faller bars. When stock reaches these bars, memory wheel has rotated to the readout section. A ball plunger actuates a hydraulic servovalve through the control arm and cam. The servo controls a hydraulic cylinder connected to the con-





MEMORY WHEEL is a mechanical delay circuit that controls action of the faller bars. Delay is required to permit the stock's moving from the measuring nip rolls to the faller bars. Three operations take place during each revolution of the memory wheel: The movable pins are cleared or reset by a fixed, wedge-shaped cam; next, pins are set by movable wedge-shaped cam controlled by amplified displacement of the nip rolls; at readout position a ball plunger is displaced by the locked pins to produce the desired delayed readout. The memory wheel has a pin every 3° —a total of 120 pins. For a period of 30° the pins are firmly locked to produce an accurate readout; during remainder of revolution, pins must move easily during input and clearing. To lock pins during readout, an eccentrically mounted wheel is used. A hard neoprene tire on the locking wheel provides the required locking pressure without damaging the pins. A felt lining allows pins to slide easily, yet has sufficient friction to prevent movement by vibration.

In operation, nip rolls are held ¼ in. apart by normal sliver stock passing through. At this normal or zero position of rolls, the linkage produces a pin length of ½ in. on the memory wheel. A heavy spot on the stock increases gap between the nip rolls and the pins are pushed in less than ½ in. A light spot in the stock decreases gap and pins are pushed in more than ½ in.



trol shaft of a variable-speed transmission that drives the faller bars. Movement of the hydraulic piston also restores the control arm and servovalve to a neutral position. Varying the feed rate of the faller bars rather than speed of the drafting roll results in a braking action that requires less power. Braking action of the faller bars varies the tension in the sliver stock between faller bars and drafting rolls. This determines extent of stretching out or drafting, and lightening of the weight of stock.

PS . . . Servo-Drafter is improved version of the pin drafter that combs several "slivers" of semifinished wool or synthetic materials before they are spun into yarn. Drafting both straightens the fibers into a parallel pattern and combines several into one of desired weight and nicely balanced —by laws of chance, heavy spots in one sliver tend to offset light spots in another. Where common practice combines up to 100,000 or more slivers to produce a single, long sliver from which yarn is made, Servo-Drafter simplifies down to a drafting operation that produces one sliver of uniform weight (within 1%). Servo-Drafter was developed by Textile Machinery Div, Warner & Swasey Co, Cleveland.

for high pressures, low velocities

. . . BONDED COATINGS LUBRICATE METAL PARTS

ALFRED DiSAPIO, *research technologist, Alpha Molykote Corp, Stamford, Conn*

Adding a solid lubricant like graphite or molybdenum disulfide to a resinous or inorganic binder gives a slippery coating that can be cured in place. Here's latest performance data on these coatings, including the newer high-temperature types.

Bonded solid-film lubricants have specific advantages. They should be considered as alternates to liquid lubricants when the following design conditions, or a combination of them, apply:

Loads are extremely high. Liquid lubricants may be completely squeezed out from between interfering surfaces —especially when loads approach the yield points of the surface materials, often causing cold-welding.

Speeds are low. At low sliding velocities, the peaks and ridges on opposing surfaces tend to penetrate the lubricant and interfere, causing slip-stick behavior or cold-welding. Here, hydrodynamic lubrication fails and boundary lubrication becomes necessary.

Surface temperatures are extreme. At present, maximum service temperature for liquid lubricants is about 600 F. Recent advances in bonded lubricants have extended coating reliability to above 1200 F and below −100 F.

Environments are dirty or abrasive. By attracting troublesome particles, liquids or greases often act as grinding compounds rather than lubricants. Typical dirty environments are: mining, road construction, and farming.

Fretting is likely. Vibration in many types of machine joints can cause fretting wear, even though there is no apparent motion between the parts. Classic examples: splined drives in aircraft engines; sleeve bearings in unbalanced automatic tools, which can fret during off periods.

Mating surfaces are inaccessible to relubrication. Permanent, in-place lubrication can be a key performance factor in many complex machines for which liquid lubrication is not feasible. Some examples: buried mechanisms in business machines, hinges and pivots in aerodynamic linkages.

Design must be simplified. Cost of supporting equipment for liquid lubrication can be high: machined oil passages, reservoirs, filters, pumps and tubing.

Users just won't relubricate. Equipment for the home, office, and vacation time must be designed for people with little mechanical aptitude or with a distaste for han-

What Is a Bonded Solid-film Lubricant?

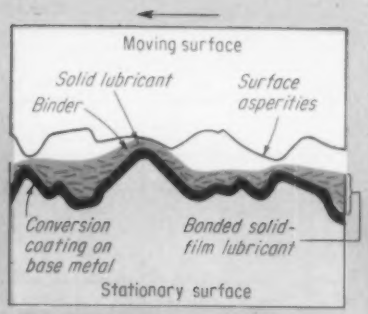
■ Many inorganic solids are slippery when finely divided. The classic example is graphite, common as a solid lubricant in bearings, lock mechanisms and the like. In powdered form, these materials can fill in the pores and valleys of mating machined surfaces—providing on-the-spot lubrication for the peaks and ridges that tend to weld together at high loads and low velocities.

A layer-lattice crystalline structure is a major key to the behavior of this type of inorganic solid lubricant. Molecular bonds within each layer are strong, whereas layer-to-layer bonds are weak. Thus, surface asperities have difficulty penetrating the layers, but slide easily over one another because the layer-to-layer bonds of the lubricant are readily sheared (see sketch). In fact, this shearing takes place more easily when loads are high—exactly the reverse of hydrodynamic lubrication. This unusual characteristic makes solid films well suited to extreme-pressure lubrication.

For an inorganic solid film to be an effective lubricant, two conditions must be met: (1) The lubricant must adhere well to the surface, and (2) The film must be replaced as it rubs off—or else applied thick enough to assure suitable life. When used in powder form, the lubricant's natural adherence to metal surfaces is most important. This led to wide use of a second major layer-lattice lubricant—molybdenum disulfide (MoS_2). In this compound, the sulfur-molybdenum-sulfur layers slide easily on one another. But within the individual layers, cohesive forces between Mo and S atoms are very strong and hence resist penetration by surface asperities. MoS_2 adheres well to metal surfaces because the exposed sulfur atoms have a strong affinity for metals.

Natural adhesion is often not enough to meet the second condition, however. Solid lubricants are then added to greases, pastes, or dispersions. This, too, has limitations: such carriers can wipe away gradually or catch dirt and other abrasives. One answer: suspend the finely divided solid lubricant in a binder-solvent system of resinous or chemically reactive nature. In this way the lubricating film may be painted on and cured in place as a permanent, thin, solid coating.

The resins may be either thermoplastic (alkyds, vinyls) or thermosetting (epoxies, phenolics, melamines); the latter require baking to give best service. Inorganic binders (sodium silicate, phosphates, borates) are sometimes employed. Solvents (alcohol, dioxane, acetone, toluol, xylene, water) vary with the nature of the binder and the application method. Three methods are most common: spray, dip, and tumble. Brushing and flow coating can be used, but do not give as uniform coatings. Baking, when necessary, is done by oven or radiant lamps.



Service life of a bonded lubricant depends greatly on the bond established between binder and base metal. Three precoating factors improve this bond: cleaning, mechanical roughening, and chemical conversion of the surface. In addition to providing micro-roughness to the mechanically roughened surface, chemical treatment gives a cushioning layer that further impedes clean-metal "welding" as surface asperities interfere.

dling lubricants. Some examples: kitchen mixers, mimeograph machines, and fishing reels.

BONDED LUBES HAVE LIMITATIONS

There are three disadvantages of lubricating parts with a cured-in-place coating.

Lubrication is nonrenewable, except by completely disassembling the mechanism and reworking the part. This means desired service life must be accurately determined and correlated with coating behavior, usually through simulated or actual wear tests (see "The Wear Tests for Bonded Lubes," p 52.)

Precoating surface treatment needs close control if best service life is to be obtained. Surfaces must be roughened to an optimum finish, carefully cleaned, and chemically etched under rigorously controlled conditions.

Bonded lubricants do not cool, as many liquid lubricants are designed to do. Thus, the heat generation problem must be carefully checked in enclosed applications.

Coating-application methods can limit design. For example: small-ID holes are hard to coat by spraying, tumbling or brushing, and must be dipped; blind holes may require special-injection jigs, even vacuum coating. On the other hand, some coatings are limited to a single method of application.

THREE TYPES OF COATING

Table I, on next page, compares eight bonded solid-film lubricants suitable for extreme loads and low velocities. These are classified into three basic types depending on their binder characteristics: air-cured, oven-cured, and inorganic-bonded.

The lubricating ingredients in all of them are molybdenum disulfide (MoS_2) or graphite, or both, along with certain of the newer experimental additives like silver, boron nitride, silver iodide, etc. Note that Table I is divided into two sections: The first five coatings are now commercially available, including Type C, a new air-curing, self-pretreating type, and Type E, a new inorganic-bonded, high-temperature type. The last three coatings are experimental high-temperature coatings whose limitations, thus far, outweigh their advantages.

Air-cured coatings use thermoplastic binders, so have lower wear life than the thermoset-based oven-cured types. However, the air-cured do have certain advantages. They can be applied by the user to parts already installed in a machine, to materials that will not take an oven-cure, and to parts too big for processing in an oven. Performance of air-cured coatings can be improved by moderate baking.

Oven-cured types have better corrosion resistance as

TABLE I — COMPARISON OF BONDED SOLID-FILM LUBRICANTS

(Coatings A through E commercially available; F through H experimental)

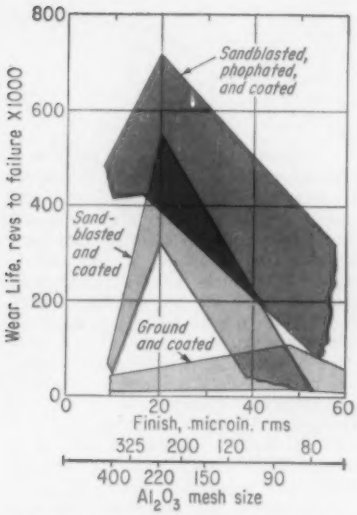
Code	Type of Coating	Major Constituents	Advantages	Limitations	Operating Temp Range, F*	Average Friction Coefficient (After short runin)	Recommended Application Methods
A	General purpose (Air cure)	MoS_2 in vinyl-butyral resin	Cures at room temperature Applicable to all metals, most nonmetals Excellent for large parts already installed	Wear life, corrosion protection of base metal, and resistance to fluid attack are all less than for B	—100 to 400	0.050	Spray, dip or tumble
B	General purpose (Oven cure) Meets Mil-L-22273 (Wep)	MoS_2–graphite in amine-modified epoxy	Excellent wear life, corrosion protection, and resistance to chemical attack High peel strength	Requires surface pretreatment for best performance Limited to base materials that can withstand 300 F for 1 hr or 400 F for 15 min.	—100 to 400	0.050	Spray, dip or tumble
C	Self pretreating (Air cure)	MoS_2 in inorganic phosphorous compound binder	Coating very thin, <0.0001 in. Coating itself pretreats surface; only degreasing is needed before application Cures at room temperature	Effective only on ferrous metals Affords little corrosion protection	0 to 600	0.030	Spray only
D	Medium temperature (Oven cure)	MoS_2–graphite–silver in a min modified epoxy	Combines wide operating-temperature range with very low friction coefficient More fluid-resistant than E	Limited to base materials that can withstand 350 F for 1 hr Less fluid-resistant than B	—100 to 900	0.020	Spray or dip
E	High temperature (Oven cure)	MoS_2–graphite in sodium silicate binder	Best coating so far for elevated-temperature service Maintains moderately low friction coefficient through temperature range	For longest life, requires two-step oven curing at 180 F and 400 F for 48 hrs	—100 to 1200+	0.060	Spray only
F	High temperature (Air or oven cure)	MoS_2–graphite in borate-phosphate salt composition	Best wear life up to 1000 F	Poor water resistance Uniform thickness hard to achieve by limited application methods Two-part system with short pot life	0 to 1000	0.050	Brush only
G	Same as E above	MoS_2–graphite–silver–boron nitride in sodium silicate binder	Better water resistance than F	Expensive constituents Requires oven cure for best results Resists wear	—100 to 1200+	0.050	Spray only
H	Same as E above	MoS_2–graphite–silver iodide in sodium silicate binder	Wear life rises as temperature increases	Acceptable wear life only at high temperatures Acceptable coefficient of friction only above 600 F (see coef. column)	600 to 1200	0.100	Spray only

* Temperature range for which reproducible data exists

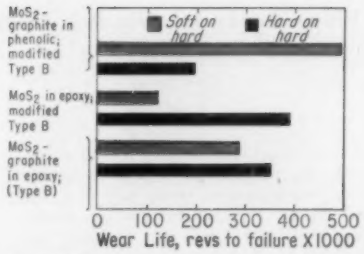
well as better wear life. However, surface preparation, coating and baking are critical and should be done by specialists for best performance. Simply switching from an air- to an oven-cured coating can increase wear life as much as 300%, as shown in the bar chart at the bottom of p 52.

Inorganic-bonded coatings are an attempt to side-step the temperature limitations of organic-resin binders. Though quite new, they show great promise once problems of water solubility, application methods and cost can be surmounted. Of the many that have been evaluated so far, only those shown in Table I seem practical.

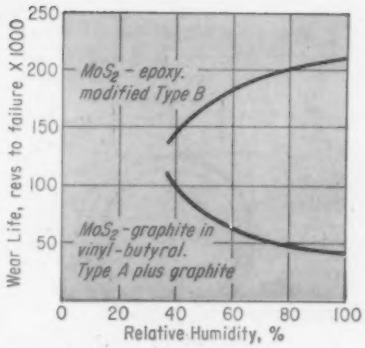
Regardless of binder, there is an optimum ratio of lubricating solids to binder content. To date, this seems in the range of 4:1 to 1:1. Cutting lubricant content much below this improves corrosion-resistance and reduces cost, but also impairs wear life. Exceeding this range, on the other hand, reduces adhesion to the base metal, lowers



SURFACE FINISH plays an important role in setting the wear life of a bonded solid-film lubricant, as shown in this chart for general-purpose, oven-cured, MoS_2 coatings. All surfaces tested here were prepared by first grinding to 8-10 microin rms, then roughening—by either sandblasting or grinding, as indicated—to the various finishes. Notice that optimum finish for sandblasting is about 20 microin, using 220-mesh Al_2O_3, whereas about 50 microin, is the optimum ground finish; also, that the 20-rms sandblasted surface gives a coating wear life about five times higher than the 50-rms ground finish. Adding a phosphating pretreatment can add another 25-30% to coating life. Bands are shown here because of wide scatter in data, taken before influence of constant temperature, humidity, and phosphating procedure was fully understood. Base materials: Blocks were SAE 4130 steel; rings were SAE 4620.



HARDNESS of the mating surfaces, a variable well within the designer's control, does influence coating wear-life. Principal problem is whether to harden both surfaces, or just the surface carrying the bonded lube. As this bar chart shows, the choice depends somewhat on the coating itself. For a coating with a hard-resin binder like a phenolic (top bars), a soft-on-hard base metal appears to give best wear. For a softer-resin binder like an epoxy (middle bars) the hard-on-hard combination is the better choice. The bottom bars are for a compromise formulation (Type B in Table I) designed for acceptable wear life under both surface hardness conditions. Line-contact method was used in these tests with steel rings hardened to 60-63 R_c. "Soft" blocks were 27-33 R_c; "hard" blocks, 58-62 R_c.



HUMIDITY can either increase or decrease wear, depending on the coating, as these curves from recent tests show. Principal constituent affected appears to be the resinous binder, though the sharp increase in wear life for the epoxy-based coating is not yet understood. Further, graphite improves as a lubricant under moist conditions because of adsorbed water vapor, thus the curve for Type A coating (Table I) might be expected to fall below the lower curve here since the coating carries no graphite. These early data show the importance of maintaining constant humidity in any series of coating-evaluation tests, as well as considering humidity variations when selecting a coating. Temperature for this series of line-contact tests was held constant at 70-75 F. Ring hardness was 60-63 R_c; block hardness, 58-62 R_c.

corrosion-resistance, and increases cost. Other performance factors such as surface hardness and roughness, service temperature and humidity, and chemical pretreatment are evaluated in the curves and charts above.

DESIGN CONSIDERATIONS

Although experience is growing rapidly, and many thousands of hours of testing are being expended, there is much yet to be learned about designing with bonded lubricants. But these precautions will prove useful:

Select the right base material. Any metal surface can be chosen, but steel is by far the most common—particularly in high-load applications. Aluminum alloys that lose strength above 215 F should be avoided if the coating chosen requires a high-temperature cure. Molded plastics and elastomers can be coated as long as the surface is roughened and solvent effects closely checked. A better way with these materials is to blend a solid lubricant into them before molding, as is done with powder-metal parts.

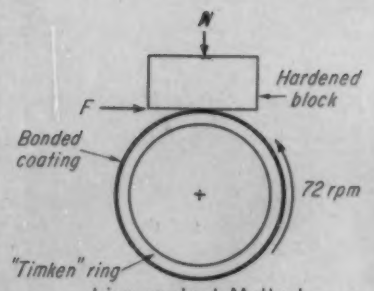
Prepare metal surfaces with care. The effect of pretreatment on bonded-lubricant performance has been shown in the charts above. Table II, p 53, shows the precise sequence of steps required for a number of common metal surfaces, including metal plating.

Determine the probable service life of the part. Bonded coatings have a finite wear life and are often hard to renew. Good limiting figures (particularly at loads above 25,000 psi) for coatings of the type discussed in this article are: 200,000 linear feet of sliding distance between components during their service life, and 40 feet per minute maximum sliding velocity on a continuous basis. Velocities above 50 fpm are apt to build up temperatures that will destroy the coating.

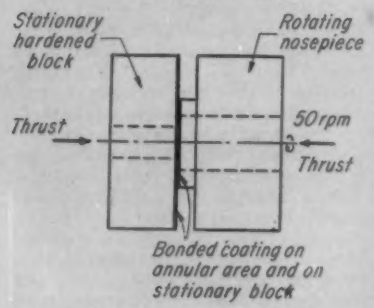
Pick the right surface to coat. Always coat the member that is constantly presenting a fresh surface area to the point of pressure. For example: coat the cam, not the follower; the shaft, not the bearing; the brakedrum, not the shoe; the ways, not the stock. This holds frictional temperatures down and distributes wear over a greater area. The results of a block-on-ring test show how this improves wear life: when the ring was coated, wear life was 196,000 cycles; when the block was coated, it was only 1000 cycles.

Check cumulative tolerances. Bonded coatings are usually 0.0002 to 0.0003 in. thick, which does not often call for alteration of established clearances between mov-

The Wear Tests for Bonded Lubes



Line-contact Method



Area-contact Method

Few wear tests are designed to simulate conditions in actual mechanisms – more often they simulate simpler components of complex surface-to-surface motions. Main objective is to create a rugged, realistic wear situation, with variables that are easily identified and controlled. Here are two such tests that are commonly used to evaluate and compare bonded solid-film lubricants (see sketches).

Line-contact test: A stationary rectangular test block is pressed with a predetermined load against a rotating "Timken" ring coated with the test lubricant. Surfaces are run in by building up the normal load, *N*, in carefully timed increments to a maximum value of 630 lbs. Initial Hertz pressure in the line-contact area is about 110,000 psi. Resulting frictional force *F* is picked up by a load cell. Friction coefficient is this force divided by normal force *N*. Wear life is taken as the number of ring revolutions for the coefficient of friction to rise from its run-in value to a previously selected "failure" value, usually 0.1.

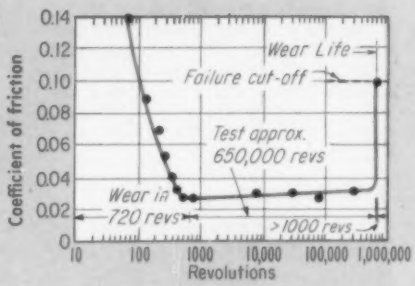
Area-contact test: A stationary flat block is pressed with a predetermined load against a rotating nosepiece having a raised annular surface area. Both surfaces are coated with the test lubricant. Thrust load after run-in is about 2500 lb, giving a bearing pressure of about 10,000 psi. Friction torque is measured and converted to a friction shear stress at the rubbing annulus. Wear life is the number of cycles for the coefficient of friction (here, the ratio of friction shear stress to axial-thrust pressure) to rise to a previously selected failure value, usually 0.15.

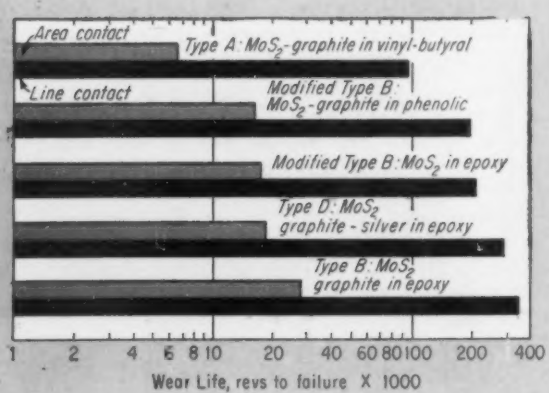
Result of these tests is a plot of friction coefficient vs revolutions as shown at right. It shows clearly the key characteristic of bonded lubricants: Friction decreases as normal load increases. Flat portion of the curve gives the coefficient of friction for the coating; its sudden upturn gives the wear life. Both these values are usually stated in conjunction with the base material used. Temperature at the contacting surface can replace friction coefficients as the criterion of failure.

HOW GOOD ARE THE TESTS?

A good wear test allows accurate comparison of many coatings by keeping the average deviation from the mean wear life to a minimum. Recent testing has shown this requires careful control of two factors: (1) pretreatment of test specimens, including both the sandblast roughening and the phosphate prefinish, and (2) temperature and relative humidity. The accompanying table shows how strict control in these two areas has brought data scatter on wear-life tests to a manageable level. Presupposed are accurate and aligned loading, rigidly maintained mating paths, identical specimen hardness and preparation, and frictional temperatures below the coating-decomposition temperature.

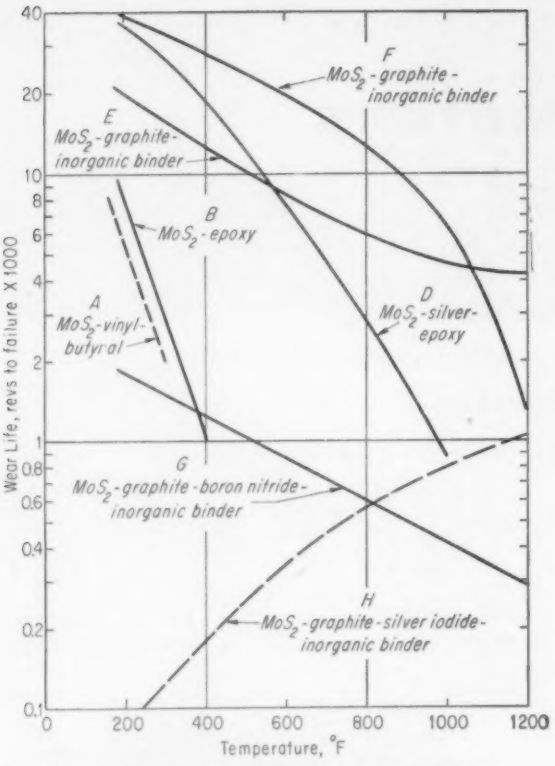
If all these conditions prevail, then different test methods should rate coatings in the same order. The bar chart below presents recent data to show that this conclusion is correct. Here, five coatings are compared by the two different test methods described above—line contact and area contact. Note that both rate the five compositions in the same order, thus the MoS_2-graphite-epoxy composition can be confidently selected from this grouping as the coating with best wear life. Extrapolation of these test wear-life figures to endurance of the coating in actual mechanisms is, of course, somewhat speculative.





Effect of Surface Treatment and Temperature-humidity Control on Wear-life Deviation

Test conditions	No. of Tests	Mean Deviation, %
(1) No strict controls: Sandblast medium recirculated and not changed often. Phosphate solution not checked often for constant composition. Temperature and humidity not controlled.	15	60
(2) Same as (1) except: New sandblast medium used, not recirculated. Phosphate solution and procedure rigidly controlled.	111	34
(3) Same as (2) except: All tests run at 75 F ± 5 F; relative humidity, 48% ± 2%	24	14



HIGH-TEMPERATURE TESTING of bonded lubricants is receiving increased attention, stimulated by military requirements. Shown above are recent area-contact wear curves for all except one of the coatings listed in Table I. The exception is Type C, a new self-pretreating coating for which a wear life of 5400 revolutions at 600 F has been determined. (Letters indicate corresponding letters in Table I.) The ideal high-temperature coating would have a horizontal curve on this chart. Note that coatings E and G approach this with excellent wear at the lower temperatures. Experimental coating H, on the other hand, approaches the ideal in the reverse direction: higher temperatures mean better wear life. Only hitch with H, so far, is how to apply it practically so it can last until the higher temperatures are reached. Other factors like peel strength and resistance to fluids are not reflected on these curves, however. Coating B, for example, has modest high-temperature performance—but is designed to meet rigid requirements in these other areas.

TABLE II—RECOMMENDED PRETREATMENTS FOR METAL SURFACES

Pretreatment	Steel (except SS)	Stainless Steel	Plated Cr or Ni	Metals Cd or Zn	Al Alloys	Cu Alloys	Mg Alloys	Ti Alloys
Degrease	X	X	X	X	X	X	X	X
Remove oxides								
Bright dip						X		
Sand blast	X	X	X					X
Anodize per Mil-A-8625A					X			
Dichromate per Mil-M-3171A							X	
Phosphate per Mil-C-1623A Type 1	X			X				
Phosphate with Lubrite SS or Granodraw SS*		X						

* Lubrite SS — Parker Rustproof Co; Granodraw SS — American Chemical Paint Co

ing parts. One exception: applications like bushings which have clearances of about 0.001 in. per in. A ¼-in.-dia bushing would have about 0.0001 in. radial clearance, too small for most coatings. Use Type C, Table I (less than 0.0001 in. thick) or widen clearance.

Do not combine solid-film lubrication with liquid lubrication. Tests show that wear life can be reduced 3 to 4 times if a bonded coating is wet with oil during operation. Design should also make it impossible to oil a coated surface. One exception to this precaution: a bonded coating can reduce run-in wear on many close-tolerance parts– such as gears and pistons. Here, design is for hydrodynamic lubrication; coating life is unimportant.

Determine the loading precisely. A satisfactory life at high loading in a lab test does not necessarily mean longer service life at lower loads. In many cases a coating will sustain more cycles at full load than at half-load. Remember these lubricants have lowest friction at high loads.

Avoid masking unless the part is large. Labor for pretreatment and application of the coating is the main cost, since a small amount of coating goes a long way. Thus, coating the entire part is usually most economical. Small parts can be tumble-coated in quantities of 10,000 and up for as little as ¼¢ per part.

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EDITOR'S NOTE: Other recent articles on lubrication and wear include the following:

Oil-mist Lubrication for Air Bearings, Aug 29 '60, p 54—New technique prevents galling and seizure during starts and stops in step-bearings lubricated by air.

Abrasive Contamination of Precision Mechanical Devices, Aug 15 '60, p 51—Latest tests with polarized light show how abrasive machining can contaminate surfaces that must slide and roll together. Two cleaning procedures are given for solving the problem.

Latest Design Requirements for Bearings and Lubricants, May 23 '60, p 56—Staff report summarizes key design equations, charts, and concepts presented at 1960 annual ASLE meeting.

How to Predict Wear Life of Rolling Surfaces, May 9 '60, p 44—New load-stress K-factors for various material and hardness combinations simplify life-expectancy calculations for gears, cams, bearings, clutches and links.

When to Specify Centralized Lubrication, May 2 '60, p 56—Article presents 5 basic systems and gives 8 factors that determine whether these methods are preferable to point-to-point manual methods.

Press-fit Test Picks Solid Lubricants for Extreme Pressures, June 22 '59, p 64—A simple way to find the coefficient of friction when surfaces slide at high loads and low velocities.

BETTER ACCELEROMETERS OFF THE SHELF

Here are the instruments you need for testing acceleration, vibration or shock; they also serve as speed controls, remote leveling devices and rotational balancers.

ROBERT J COHEN, *Kearfott Div*
General Precision, Inc
Clifton, NJ

Need an accelerometer? You're in for a surprise if you haven't shopped lately for one of these acceleration-measuring devices. The past few years has seen them become specialized–and sophisticated.

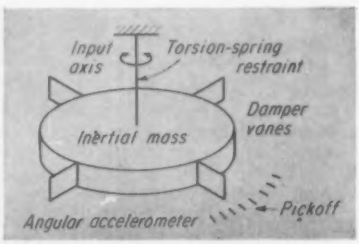
Choosing the right one requires making some comparisons but is well worth the time because chances are you can now get one straight out of stock to fit your specific needs. What's more, as a result of your investigation, you may find other uses for these sensors. For example, bubble-type accelerometers are now available as low-cost, remote-control leveling devices–an application unheard of only a short time ago because of cost.

HOW THEY WORK

All accelerometers are mechanical systems that employ at least three elements: a seismic (inertial) mass, the spring restraining it, and a reference structure or housing. When acceleration is applied, the mass tends to stay motionless in space. But the housing moves. The displaced mass remains in dynamic equilibrium for the duration of the acceleration. The force produced by the acceleration acting on the mass is absorbed by the restraining spring. When acceleration ceases, the spring returns the mass to its original position relative to the housing. For maximum accuracy, highest input-acceleration frequency must be at least one octave below the mechanical resonant frequency. Output (displacement of the spring) thereby becomes directly proportional to the acceleration expressed in g's (32.2 ft/sec^2).

The seismic mass can be either a simple pendulum or a translational mass that moves linearly within its housing. The springs are either mechanical (hairsprings, cantilevers, torsion bars) or electrical or hydraulic servomechanisms. Output displacement, measured by the spring displacement, may range from inches in a conventional unit to microinches in the servomechanism.

Angular accelerometers operate on the same principle except that the spring restraint is torsional rather than linear and the seismic mass is well balanced to resist displacement by linear acceleration. The customary way to express angular acceleration is in terms of radians per sec^2.



Output of this accelerometer can be an optical readout, such as a pointer. More often, it is electrical: self-generated voltage, as in piezoelectric type; variable resistance ac excited by external voltage source, as in strain gage; differential transformer; or feedback current or voltage, as in servo type.

Specifically, here are the six types covered in the table on p 56.

Electrolytic-bubble Pendulum

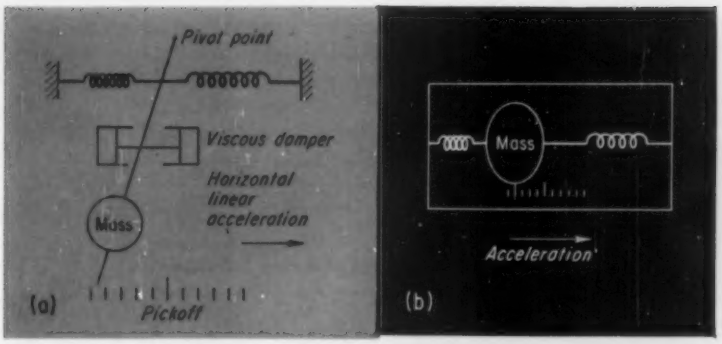
Simply a common bubble level filled with an electrolyte. It serves as a restrained pendulum. Acceleration causes movement of the liquid; movement causes change in resistance of electrolyte between electrodes.

Piezoelectric

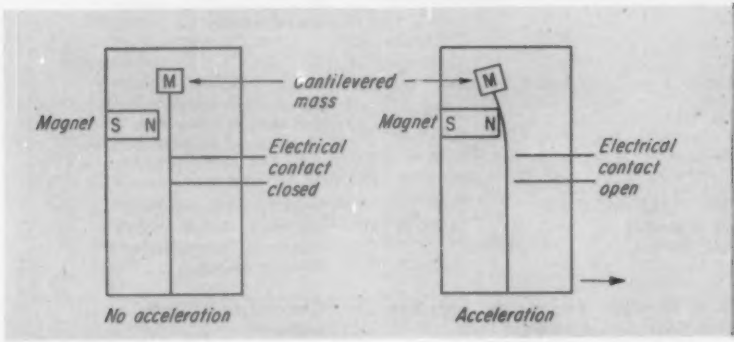
Generally a translational-mass rather than pendulum type, because it is most often used to detect vibration. Force of acceleration causes the mass to produce strain on the barium titanate, which generates a signal.

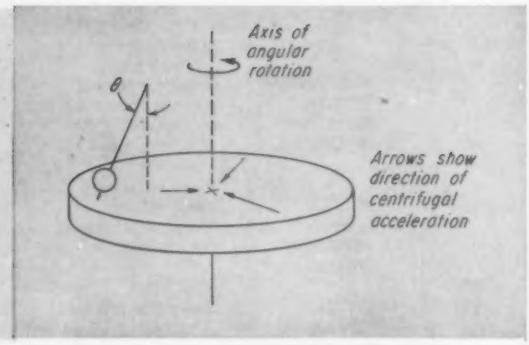
Strain Gage

Primarily pendulous. The mass deforms (strains) a resistance element which is externally excited. Deformation results in change in resistance, and so, a change in signal, which can be either ac or dc.



ALL ACCELEROMETERS use one or the other of these two principles: (a) Simple pendulum; (b) Translating mass.





TWO APPLICATIONS for simple accelerometers. Left: inertial accelerometer switch can serve as safety switch —guard against excessive vibration or act as crash-actuated disconnect switch for autos or aircraft. Right: a wheel-speed governor. Pendulum angle produces electrical output which can be picked off through slip rings. When wheel reaches speed limit, pendulum angle reaches preset maximum, giving signal needed to turn off or limit power.

Mechanical Spring-restrained Pendulum

Output can be simple pointer or electrical, such as synchro, potentiometer, etc.

Servo Spring-restrained Pendulum

Very precise and sophisticated. It consists of a pendulum, an electrical pickoff, an amplifier, and a torque motor. The pickoff output is amplified and fed back to the torque motor, which drives the pendulum back to null. Feedback current or voltage is measure of acceleration and acts like a very stiff electrical spring. When this accelerometer is operated as an inverted pendulum, it becomes a very precise leveling device.

Gyro Pendulum

Has no practical commercial application yet. Is very expensive, and included here for comparison only. As noted in the table, it is used in inertial-guidance systems.

The device is a gyro mounted in a pendulous gimbal. The acceleration-produced torque appears about the output axis of the gyro as a precession torque. Gyro responds by rotating the gimbal about the accelerometer output axis at an angular velocity sufficient to balance the acceleration torque. The angular velocity about the accelerometer output axis is proportional to acceleration. Total angle about the output axis is proportional to the integral of acceleration (linear velocity). A variation of this device can perform double integration, thus serve as a true inertial odometer or distance meter.

ANALYZING YOUR REQUIREMENTS

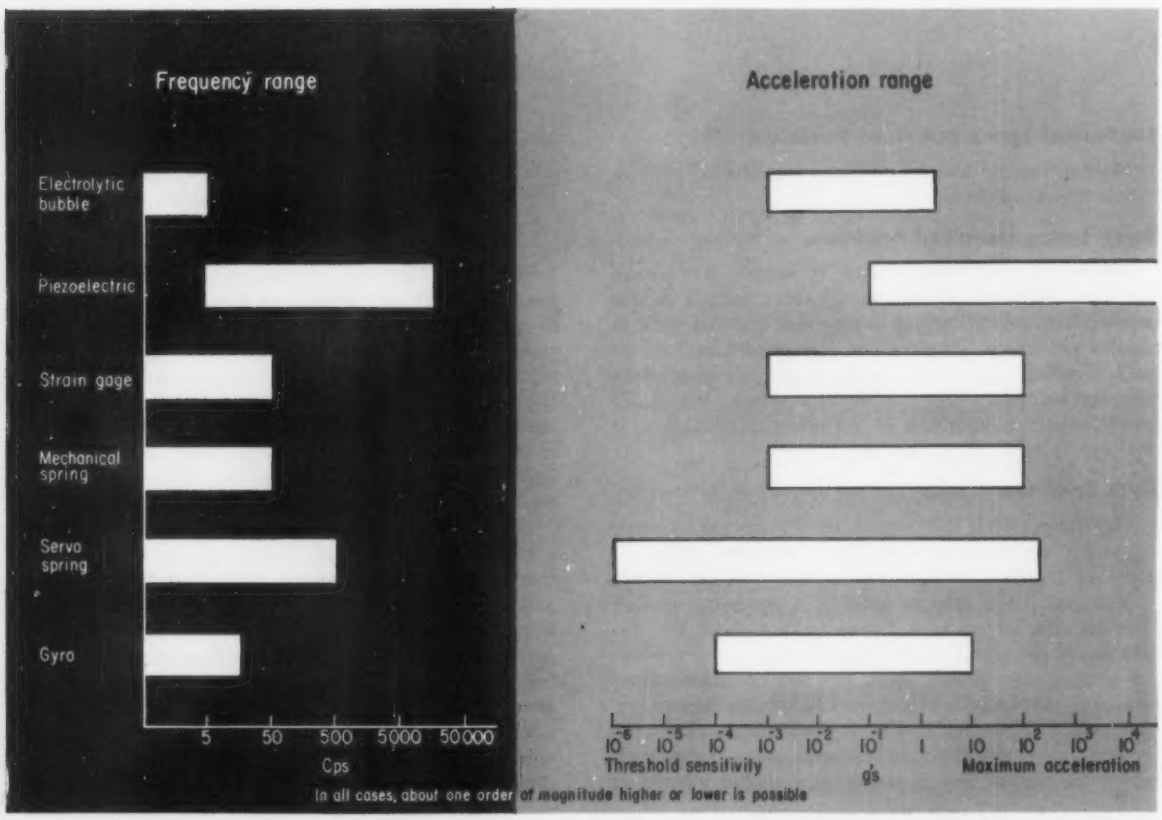
The table, on next page, covers major types now on the market. Its bar graphs are approximations that give an idea of relative values between types. As you determine your acceleration and frequency needs, you can check the graphs to eliminate certain types. For instance, if you discover you must operate at 1000 g or more, you see immediately that only a piezoelectric type will do. If you require something in the 5-g range, you can choose among several types, depending on other characteristics such as cost or accuracy.

Suppose you want an accelerometer to determine peak acceleration during shock; then high natural frequency, maximum range, and small size are important. A glance at the table tells you the piezoelectric accelerometer is the best choice. Or suppose you need a control element for an aircraft autopilot. You would then need good resolution, high ac output per g, fair null repeatability, and a range in the order of a few g's, positive and negative. Here you have a choice of several types. The one most generally chosen is the mechanical spring-restrained pendulum.

text continued on page 57

SIX TYPES OF ACCELEROMETERS

Type	Performance	Size	Accuracy (% of Reading)	Cost	Applications
ELECTROLYTIC-BUBBLE PENDULUM	Power output in watts; good null repeatability	½ cu in.	5	low to medium ($10 to $100)	Remote leveling devices
PIEZOELECTRIC	Good for vibration measurements. Self-generating signal, generally requires amplification	1/3 cu in.	5 to 10	low	Vibration, shock tests
STRAIN GAGE	Must be externally excited, ac or dc. Low output, (millivolts/g); good resolution	1 cu in.	1 to 5	low to medium	Acceleration and vibration tests, leveling devices, speed controls
MECHANICAL SPRING-RESTRAINED PENDULUM	Good for sensing constant linear acceleration rather than vibration; good resolution	1½ to 3 cu in.	0.1 to 5	low	Inertia switches, balancing machines, acceleration tests, leveling devices, speed controls
SERVO SPRING-RESTRAINED PENDULUM	Very stable; repeatable, linear, but complex	2½ to 10 cu in. (including amplifier)	0.02	high ($500 & up)	Velocity meter, stabilized platforms, building-vibration tests, balancing and leveling devices
GYRO PENDULUM	Sensor for inertial guidance	30 to 50 cu in. (including amplifier)	very precise (classified)	very high	Can replace airborne platforms



A velocity meter (accelerometer plus external integrator) requires highly-linear output characteristics, good null stability, and low cross-acceleration errors. For this application you need a servo type, or a further sophistication of the servo—the pendulous gyro. Cross-acceleration is a spurious output caused by inability of the sensor to distinguish between accelerations along the desired axis and its other coordinate axes. Because an ordinary pendulous accelerometer is inherently sensitive to cross-accelerations, only a tightly restrained pendulum or a translational-mass instrument will do.

Balancing devices need good threshold sensitivity, so here you have a choice of servo, nonservo, or strain gage.

Speed controls require good resolution (ability to distinguish between small, incremental changes in acceleration). A mechanical spring-restrained pendulum or strain gage will do the trick.

If you are building an inertial-guidance system you'll want long-term stability of output scale factor, highly linear performance, and freedom from spurious outputs during combined vibration and linear acceleration. The gyro type was developed specifically for this purpose.

ASK THE RIGHT QUESTIONS

These questions will help analyze your requirements. The answers add up to specifications for your supplier.

1. Accuracy?
2. Range?
3. Servo or nonservo?
4. Scale factor?
5. Ac or dc output?
6. Excitation frequency level desired?
7. Damping ratio?
8. Input impedance?
9. Output impedance?
10. Threshold sensitivity?
11. Vibration environment?
12. Temperature environment?
13. Resonant frequency?
14. Cross acceleration tolerated?
15. Package size?
16. Weight?
17. Price range?
18. Tolerance to magnetic fields, ac or dc?
19. Effect tolerated by adjacent devices?
20. Application — velocity meter, accel., vertical sensor?

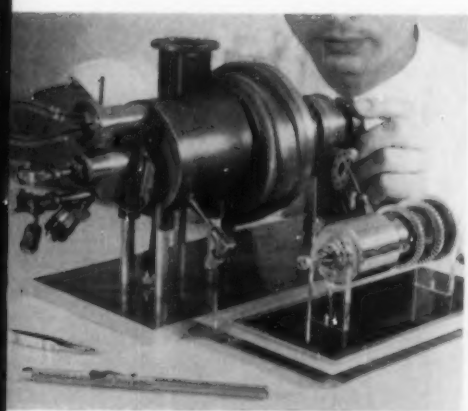
For REPRINT of above article, just check P60 on one of the Reader Service cards in this issue.

EDITOR'S NOTE: For additional information on force sensors, see:

Piezoelectric Transducers Measure Fluctuating Forces, Pressures, Accelerations, Apr 27 '59, p 61—Tells how piezoelectric accelerometers work; their limitations and applications.

Pressure-sensitive Material Measures Explosion Forces Sep 16 '57, p 106—Properties and application data on pressure cells made from rare earths. Cells change electrical resistance when compressed.

FOR POWER IN OUTER SPACE: Mercury Turbine + Nuclear Reactor



Prototype turbine uses mercury vapor at 700 F as the heat-transfer fluid; rotates permanent-magnet rotor to generate ac power. Separate 200-lb sodium-cooled nuclear reactor vaporizes mercury; condenser dissipates heat by radiation to cool it to liquid. Total weight of system is 600 lb, including reactor and shielding.

Mercury is teamed with a nuclear reactor in a newly developed, lightweight power source for space applications. Mercury vapor runs a turbine that generates power for both propulsion and auxiliary equipment; mercury liquid lubricates the turbine shaft bearings.

Sponsored by the AEC and WADD, Thompson Ramo Wooldridge has built prototypes of this Rankine-cycle turboelectric power system that have already completed over 2300 hours of operation. Called SNAP II, the display model shown in photo can produce about 3 kw. At right is mercury pump, alternator and turbine; casing for complete unit is shown at left.

Here's how the system works: Mercury vapor, heated to 700 F in a boiler, drives a 2-stage turbine at 40,000 rpm. Liquid sodium transmits heat from reactor to boiler. Alternator —a permanent-magnet rotor with stator—generates ac. Turbine, alternator and mercury pump are mounted on single shaft in hermetically sealed package. Electromagnetic liquid-sodium pump is driven by permanent magnet rotating on main shaft. From turbine, mercury vapor is directed through condenser and subcooler to convert it back to liquid state. Condenser fins and shielding are made of beryllium.

Liquid coolant results in small-dia tubes and headers, and saves weight in protection against meteorites.

The first operational units are slated to produce under 50 kw. New alloys, able to stand higher temperatures, are expected to lead to a 300-kw plant; and by 1970, a multimegawatt system, operating at 2000 F, may be available.

High-energy content of such a nuclear power system offers important advantages over solar radiation as a power source in outer space. Solar reflectors are subject to meteorite damage, require orientation and call for far larger exposed areas. An experimental reactor has already completed a 1000-hr uninterrupted test.

LATEST TECHNIQUE IN

Camera-made drawings

Take a photo of the model or prototype, let the draftsman sketch in the details, and you've got an assembly drawing that's faster and cheaper to produce, easier to read. Author describes two important improvements in the photodrawing method and cites two case histories that show what it can do.

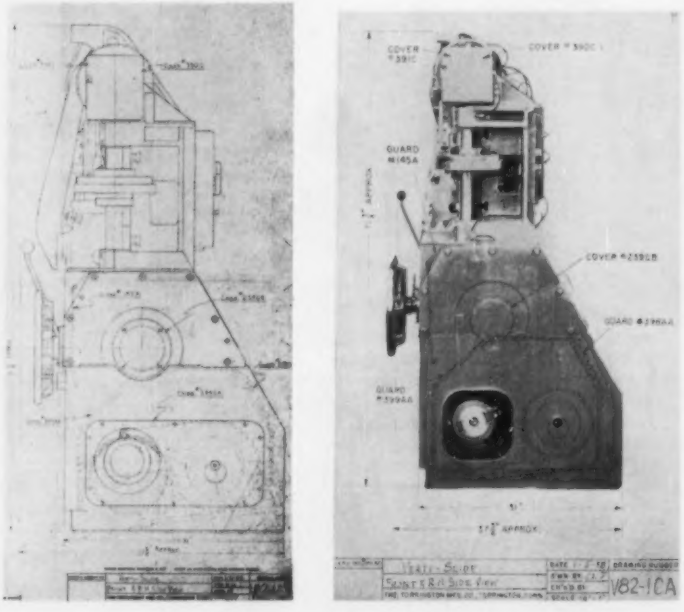
GORDON O F JOHNSON, *vice-president, LogEtronics Inc, Alexandria, Va*

Suppose we have to reverse the usual procedure. What method—in assembly drawings, for example—will transform the 3-dimensional prototype back into a 2-dimensional drawing? Traditionally, this has meant another full-dress drafting job. But why not exploit the advantages of a very common instrument—a device that turns three dimensions into two at the click of a shutter?

Putting a camera to work this way is not a new idea. But until recently most results with photodrawings have been disappointing because of technical limitations.

It's difficult to get ideal lighting for an entire piece of hardware, so some parts of the negative are bound to be overexposed, others underexposed. The result in either case is loss of detail. And to produce the abundance of prints necessary, it is preferable to use the same diazo reproducing machine that's used for line drawings; but with ordinary techniques diazo prints are too contrasty to be acceptable, particularly when a second generation of prints is made from diazo intermediates.

Two improvements in the photodrawing method have



ENHANCEMENT OF DETAIL is one reason why the photodrawing (far right) is superior to the line drawing. The Torrington Manufacturing Co has found that the method also saves nearly $300 for the complete 2-view drawing (only one view shown). Costs are shown at top of facing page. Photodrawing in center made directly from negative (via positive transparency) without dodging or control of contrast, is unacceptable because reflections in center portion and shadows in lower portion hide necessary detail. Positive transparency for preferred photodrawing was made from the same negative with a LogEtronic printer.

PHOTODRAWINGS IN A MEDIUM-SIZE COMPANY

The Torrington Manufacturing Company is not large enough to have its own photography department or afford the special equipment needed to prepare master photodrawings. Normally they take their own photographs but employ a local commercial reproduction service to prepare the controlled-density, screened positives for subsequent linework by Torrington draftsmen.

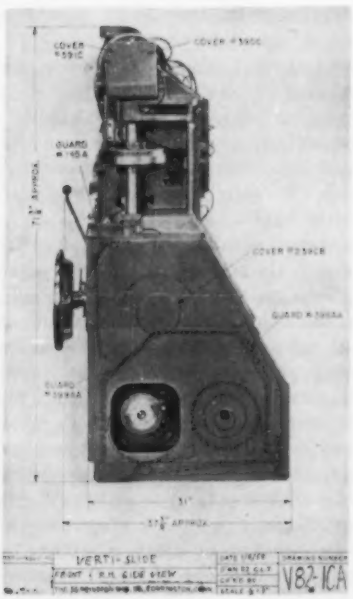
The three partial drawings of the Torrington V-82 four-slide machine at bottom of these pages show the differences between the old and new methods. Erman J. Cavagnero, chief design engineer of the Machine Division, estimates that the assembly drawing for elevation and end views of the machine costs about $380 when prepared by a draftsmen. By contrast, the breakdown of costs for the photodrawing is:

2 *Photo negatives*	$15.00
2 *Autoscreen positives*	22.00
1 *Direct-positive film (15 x 24 in.)*	4.20
Drafting cost	56.00
	$97.20

These costs include normal profit of the commercial reproduction service but do not include cost of making controlled-contrast prints in the LogEtronic enlarger. The increase in cost for the specially processed positives is estimated at between $1 and $2 apiece. (This cost is not yet firmly established because the outside firm, New England Blueprint Co, Springfield, Mass, has only recently installed the special machine. This is the first such installation by an independent reproduction service.)

Torrington anticipates it can also use the process to make fast, inexpensive copies of photographs for needs elsewhere in the company. It estimates that it takes about 300 photos a year and makes about 10 copies of each. The 3000 prints (8 x 10 in.) are ordered at a unit cost of 40¢ each. With screened positives of each negative at a cost of $2.50 each, copies can be made on the diazo machine for a material cost of ¾¢ for matte finish paper and 15¢ for the new high-gloss diazo paper. This saves about 12¢ per high-gloss print, assuming 3000 prints.

TORRINGTON DRAFTSMAN adds dimension and hidden lines to a composite photodrawing—two views of the V-82, four-slide machine. Screened positive tranparencies have been taped to the back of a matte-surface drafting film. When linework is complete, this becomes the master photodrawing.

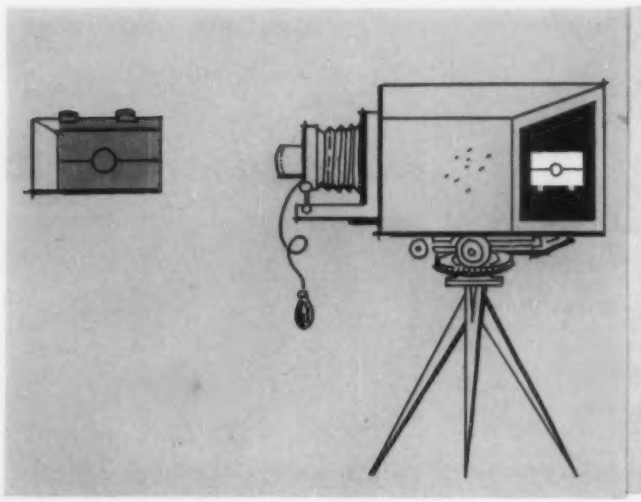


changed all that. An electronic enlarger has been developed that automatically compensates for poorly exposed negatives; and use of a halftone screen ensures detailed, magazine-quality diazo prints for copies beyond the first generation. These two methods are primarily responsible for the renewed interest in photodrawings.

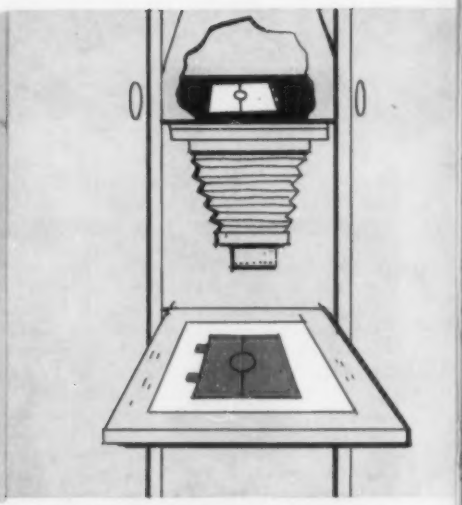
Photodrawings don't eliminate the draftsman. He is still needed to make drawings of individual parts of the assembly—and any other drawings where there is no physical part to photograph. Even the photodrawings require some drafting work—dimensions, part callouts, labels, hidden lines.

Why make an assembly drawing if the machine has already been assembled? Usually, of course, this first machine is only a prototype, put together from sketches and notes; and undoubtedly with the project engineer breathing down the machinist's neck. The photodrawing tells production personnel how to repeat this process. It's not necessary to have a complete, working prototype; full-scale appearance models, mockups, even small-scale models can serve the same purpose. Photodrawings are also convenient when engineers want to make changes or custom modifications of a machine that is already in

From 3-D to 2-D prints—four simple steps



1 CONVENTIONAL CAMERA gives negative image; photographer makes one negative for each view required on the assembly drawing



2 POSITIVE TRANSPARENCY is made from negative and "dodged" to adjust for variations in exposure. Halftone positive is made when requirements are critical.

production. Their advantages over line drawings are:

Low Cost. Except for simple shapes, photodrawings are considerably cheaper than comparable line drawings. Because cost of materials is about equal, the major difference is cost of drafting effort. Savings range from 50% for a relatively simple drawing to as much as 95% for drawings with many parts and complex spatial relationships.

Speed. Only a small amount of time is required to take the photo and process it to the point where the draftsman can add the necessary lines. The major portion of the time required to produce a photodrawing is still the drafting time. Hence, as with cost, time savings are roughly in proportion to saving in drafting effort.

Accuracy. Cameras don't make mistakes, so the drawing checker only has to look at the lines added by the draftsman. Further, the photo shows shading, texture and depth, making the assembly easier to visualize and reducing error at the production level. The symbols, sections and special pictorial representations of line drawings can easily confuse personnel unfamiliar with standard drafting notation.

THE FOUR STEPS

Start With a Good Photo

The sketches above show the four steps in making a photodrawing. First requirement is a good photo of the prototype, model or mockup. Usually it is taken by the firm's own photography department. The small company that does not have its own cameraman can call in a commercial photographer without adding much to the cost of the process.

The photographer should be cautioned to avoid shadows or highlights that obscure needed detail. He should also choose a camera angle that minimizes perspective as much as possible. He should not try to include too much information in one view by taking photos from oblique angles—one picture for each of the views, as they would appear on a line drawing, is the best practice. Whenever convenient, the assembly should be photographed in a studio where there is better control of lighting and camera angle.

Make a Controlled-contrast Positive

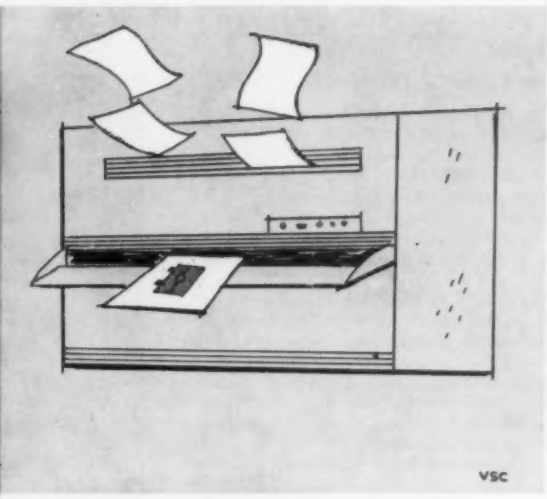
A perfectly exposed negative is rare, even for a skilled photographer taking proper precautions, so special handling is necessary, especially since prints of the master photodrawing (a positive transparency plus the details added by the draftsman) must be made on the same diazo machine that is used to reproduce line drawings.

Loss of detail because of lighting variations in the negative can be overcome by careful preparations of the positive transparency. One way is by skillful "dodging"—a good photographic technician can use a conventional enlarger to compensate for uneven exposure by blocking off light from the lighter parts of the negative while allowing darker parts to receive more exposure.

A more precise solution is with the special enlarger that automatically makes properly exposed prints from poorly exposed negatives. Such an electronic enlarger is made by LogEtronics Inc. (For details of its operation, see photo and diagram at right.) Its original application was to preserve vital photographic detail in aerial photography. Now, it is found in almost every field of photography, from electron micrographs to high-fashion photography. The cost of the basic B-5 LogEtronic enlarger is about $10,000. The development of this machine is considered by many as one of the most important steps toward making photodrawings practical.

Improvement in the amount of detail in converting from negative to positive is only one of the reasons why

3 LINEWORK IS ADDED to the positive by a draftsman. It's done directly on matte-surface positive or on a drawing film taped over it.



4 PRINTS ARE MADE in the conventional diazo machine with the same sensitized paper used for line drawings—no special skill or materials needed.

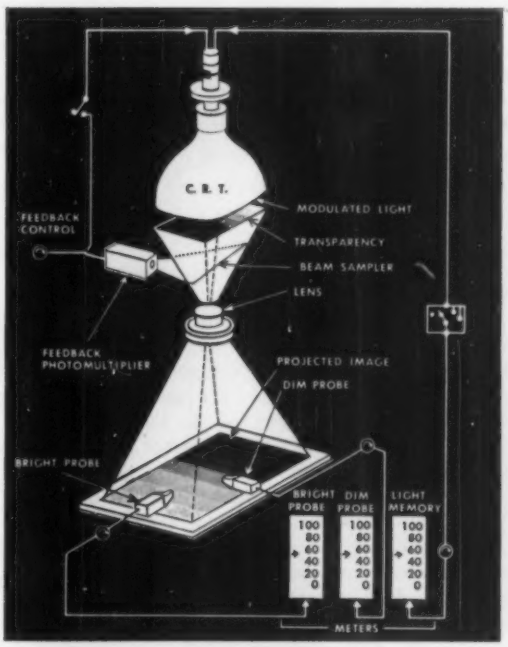
use of the LogEtronic enlarger is considered an essential step in the photodrawing process. There are two other reasons–both just as important.

First, the electronic enlarger can be adjusted to compensate for the discrepancy in contrast range between photographic emulsion and diazo print paper. Photographic emulsion has a broad contrast range (typically about 1.7 units from whitest white to blackest black) while diazo print paper has a narrow contrast range (as small as 0.2 in some cases but rarely larger than 0.8). This narrow range of contrast is ideal for the drawings–a line either reproduces or it doesn't–but it is unsuitable for prints of continuous-tone transparencies made the usual way. Such prints are too contrasty–some of the dark grays on the positive appear black on the print while some of the light grays appear white. With the electronic enlarger, the photographic technician can adjust the contrast range of the positive transparency to any desired value. For photodrawings, he will select a contrast range that matches the contrast range of his diazo print paper. Thus, all subtle shadings on the negative will show up on the diazo print.

The second advantage of the controlled-contrast process is that all the positive transparencies receive exactly the same exposure. This is important when individual positives are combined to make a two- or three-view photodrawing. Without controlled-exposure positives, it is likely that diazo prints made from these composites would have some views that were too dark, others that were too light.

The contrast problem recurs when second generation diazo prints are made from first-generation diazo intermediates as required in most military contracts. Here, the solution is to use a halftone screen when making the positive transparency. This screen breaks the positive image into a series of tiny dots, all having the same

ELECTRONIC ENLARGER made by LogEtronics Inc automatically eliminates unwanted variations in contrast on the negative. The schematic shows how it works. The light source, a cathode ray tube, scans negative and exposes the print, one spot at a time. Intensity of spot is monitored and controlled by the feedback photomultipler between negative and lens. Two light-sensitive probes permit photographer to adjust image brightness-range and contrast to match emulsion on print.



PHOTODRAWINGS IN A LARGE COMPANY

General Electric's Large Jet Engine Department in Evendale, Ohio has its own photography department, with a staff of 12 photographers and lab technicians. Since 1951, GE has been using photodrawings to replace some of its line drawings; today, virtually all engine-assembly drawings are made this way.

A typical jet-engine assembly drawing is shown in the photo at right. The sheet of screened, positive transparencies (master photodrawing) is being microfilmed as required for military records.

The drafting-group supervisor estimates that this drawing, if conventionally prepared, would require at least 600 hours of drafting time, over a period of probably six to eight weeks. The photodrawing was produced in 30 hours—10 in the photography lab and 20 in the drafting room. Thomas E. Ware, supervisor of photography, points out that the 20-to-1 cost and time reduction is not the only benefit: there is more information in the photo and chance of error is reduced.

The Large Jet Engine Department has a LogEtronic contact printer (a simpler device operating on the same principle as the enlarger) in its photo lab and it is used to make all positive transparencies for photodrawings. These are printed on Eastman Kodak Autoscreen film. The special printer is a later acquisition—the first jet-engine assembly drawings were made without automatic contrast control. These had several drawbacks. First, the master photodrawings did not give clear prints and many detailed parts of the assembly were obscured. This made it necessary to add supplementary close-ups to the medium-distance photos in the drawing. An average of 30 photos was needed to show the assembly in all its detail. With the electronic printer this number has been reduced to 10.

Moreover, because there was a wide variation in contrast among photos, each of 30 views was previously put on its own 11 x 17-in. sheet, and the diazo machine frequently had to be reset when a new view was printed. With the LogEtronic printer, contrast is consistent and detail is increased. Thus, the same size views can be put on one size E (34 x 44 in.) sheet and processed together. The single sheets are more convenient, require less storage space. When changes are necessary, the master drawing can be modified by stripping in a new view.

density. The size of each dot is directly proportional to the intensity of incident light. The tone of prints made from half-tone positives depends less on the response of the printing paper and more on the size of the dots. Light areas have small dots; dark areas have large ones.

Normally, a screen of at least 100 lines per inch is recommended. The electronic enlarger is adjusted to give a 20% dot in the highlight areas and a 70% dot in the shadows. Another way to make a screened image is with Eastman Kodak Autoscreen film. This needs no screen in the enlarger because there is a 133-line screen built into the emulsion.

Add Linework

When the positive transparencies have been prepared, next step is to add the necessary linework. There are two common methods.

Suppose the desired photodrawing is to include three views of the assembly—top, side and elevation. The three positive transparencies can simply be taped in their proper position on the back of a piece of drawing film or vellum and the lines drawn on the top.

The other way is to make a contact print on an intermediate film. Here the problem is to make a composite positive intermediate from the individual positive transparencies. The individual transparencies can either be arranged in their proper positions on a single sheet of matte-surface, direct-positive, sensitized film and a contact print made; or the transparencies can be placed on a sheet of diazo-sensitized, matte-surface film-intermediate and exposed in the diazo reproducing machine. In either case, the additional lines, dimensions and labels are added directly on the matte surface of the film. This then becomes the master photodrawing.

Make Prints on Standard Machine

Master photodrawings prepared this way can be handled the same as conventional line drawings. They are stored and revised in exactly the same manner and prints are made in the diazo machine as before. Reproduction is the final step. No special skill is required and, with equal-density masters, the same machine setting gives perfect prints for every photodrawing.

The quality of prints is very good indeed. The screened positives ensure good definition, and a tonal quality equal to the best magazine photographs. Many companies have been so pleased with the quality of photographs made on their diazo machines that they regularly use the process to make copies of photographs. Numerous copies of photos for booklets, reports, sales brochures and many other individual uses can be made quickly and inexpensively by this process.

EDITOR'S NOTE: For other ways to reduce time and effort in the drafting room, see:

13 Ways to Cut Drafting Costs, Sep 28 '59, p 54—A checklist of modern methods and materials.

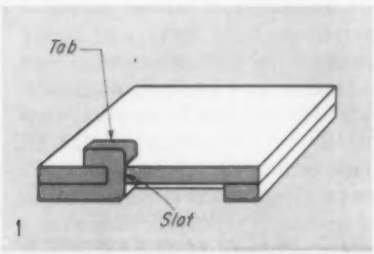
Drafting Costs Are Going Up, June '57, p 166—They represent 70% of total engineering cost . . . Why?

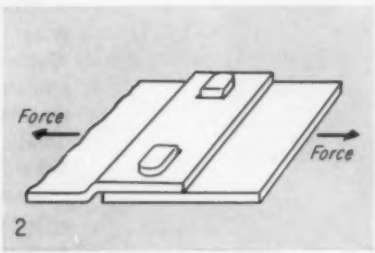
Drafting Cost Reduction, June '55, p 193—Nine ideas that reduce cost without overdoing "simplification."

Lanced Metal Eliminates Separate Fasteners

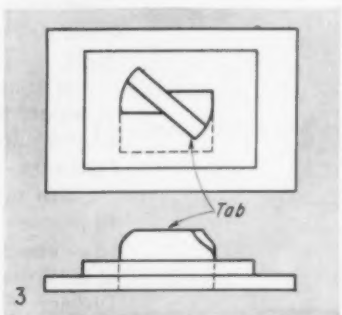
FEDERICO STRASSER
Mankowitz & Strasser
Santiago, Chile

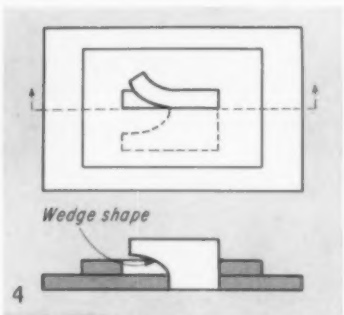
15 ways in which sheetmetal tabs, ears and lugs can serve to fasten and locate.



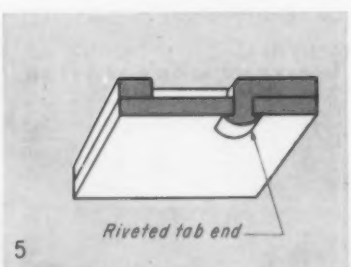


BENT-OVER TAB holds together up to four layers of sheetmetal. Designing tabs to stress in shear increases holding strength.

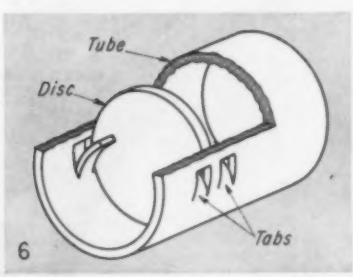


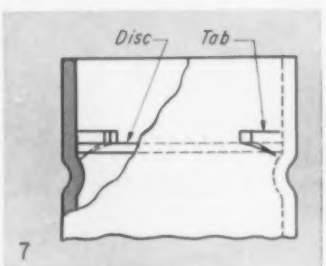


TWISTED TAB is less common than bent one. Shaped tab wedges tightly when twisted.



WITH THICK STOCK, end of tab can be riveted.





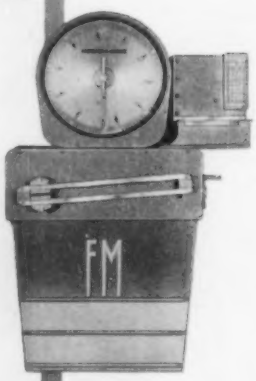
THESE TABS both locate and hold disk in tubing. When necking locates disk, tab only holds—again by wedge action.

continued on page 65

NOW... an accurate printed record of everything you weigh

Automatically!

- Time, date and other identifying symbols may also be recorded simultaneously with weight.
- Weights are printed in digits 5/32" high.
- Also available: consecutive numbering devices, repeaters, coin operating mechanism, balance detector, roll tape and ticket printing, open throat design printer that permits weight tickets to be inserted from either front or side.



Yours at the touch of a button with the Fairbanks-Morse PRINTOMATIC WEIGHER

THE VERSATILE ATTACHMENT that fits any F-M Floaxial Dial Scale to provide you with accurate permanent printed records. Completely eliminates the possibility of human errors in weighing operations; does away with costly disputes between buyer and seller, weighman and trucker. Instead, you get *truly automatic weighing* . . . the Floaxial Dial Scale plus Printomatic accurately record correct weights on tickets, roll tape or both!

WAREHOUSES *find Printomatic valuable in effective cost control. Printomatic furnishes a printed, permanent record of every shipment entering the warehouse—an effective check on the cost of raw materials.*

INDUSTRIAL OPERATIONS *often include Printomatic* directly on the assembly line *to accurately weigh and tag products and product parts.*

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Learn how truly automatic weighing, the Fairbanks-Morse Printomatic way, can make your operations more efficient, more profitable. Write to Fairbanks, Morse & Co., Scale Division, Fair Lawn, New Jersey.

Fairbanks, Morse

SCALE DIVISION

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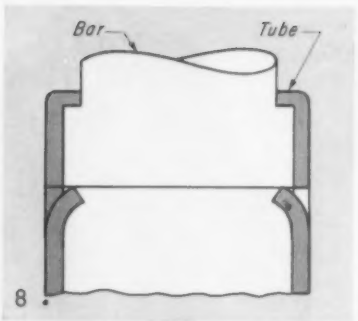
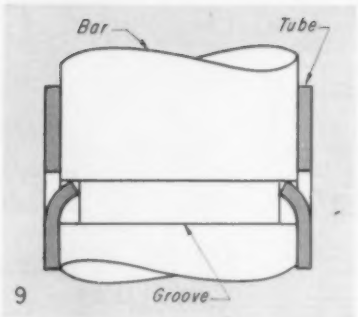
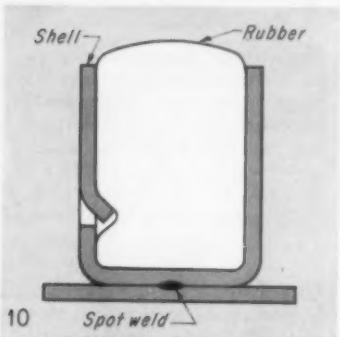
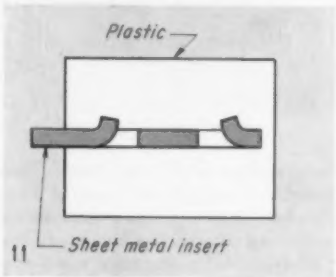


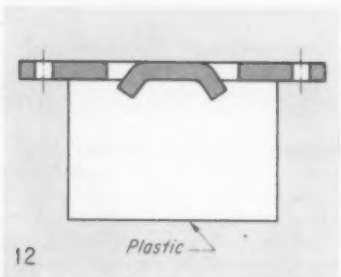


LIP AND TABS combine to join round bar and tubing. For longer bars, tabs fit into grooves. Bar can rotate inside tube if tabs are pressed lightly into groove.

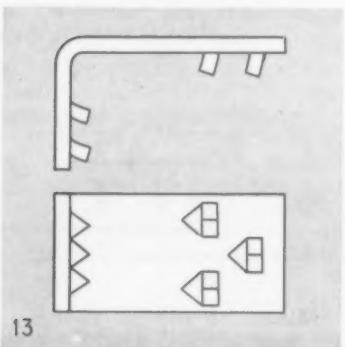


LANCED SHELL secures rubber in bumper or instrument foot.

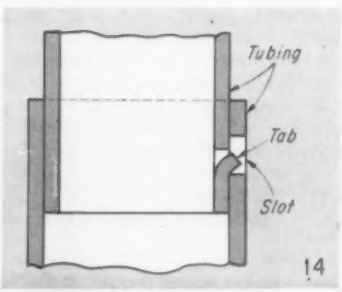




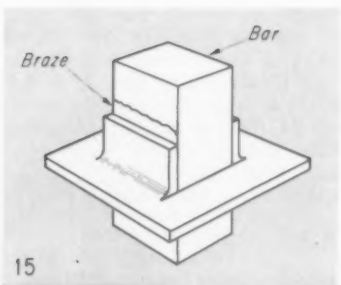
METAL REINFORCEMENTS and mounting pads grip plastic better if lanced.



CORNER REINFORCEMENT grips wood, plastic or fiber with lanced teeth. Similarly, lanced nameplates or labels attach easily to equipment or instrument panels by pressing into the surface.

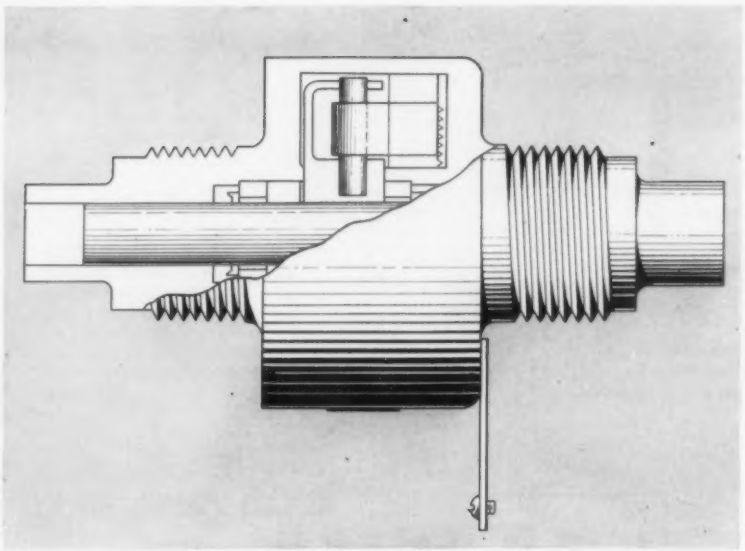


INTERLOCKING SLOT and tab connects two pieces of tubing. Joint is permanent if inner tubing has thick wall. If inner tube has thin wall, tab can be depressed and tubes pulled apart if desired.



LANCED FLAPS provide large contact areas for brazing or soldering sheet-metal fins to bars and pipes. An alternate method for round bars or pipe is an embossed collar around the hole. However, for angular shapes, flaps are easier to make.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Motion detector senses low speed . . .

or no motion at all. Senses increments of rotary motions as little as, or less than, ½ rpm—can also be utilized to detect linear motion by simple conversion to rotary motion. Rotation of driveshaft forces sensing blades, partially submerged in silicone oil, to swing up and away from contact plate, opening circuit. Continuous rotation causes blades to plane on oil. Upon stopping rotation, blades swing down and contact plate again, closing circuit. Can be constructed to close circuit at zero, prezero or for time-delay functions in response to motion in either direction. Device, housed in nylon, is approximately 2½ in. high and weighs a few ounces. Operates in temperatures of —40 to 240 F. Reported not to be affected by magnetic fields. Originally designed to prevent automobiles with automatic transmissions from creeping while idling in gear. Available in limited quantities for specific applications. **Research Div, Gaylord Products Inc, 1918 Prairie Ave, Chicago 16.**

Circle 300 on Reader Service Card

Precision shafts for miniature bearings . . .

are centerless ground of Type 303 stainless steel in diameters selected for free to light push fit into the bores of the nine standard-size miniature bearings. Available in stock lengths ranging from $\frac{5}{16}$ to ¾ in. for 0.0463 in. bores, to 1¼ to 6 in. for 0.3125 in. bores. Stock lengths are in about 20 steps for each diameter, with steps selected statistically on basis of most frequent use. Ends are chamfered 45° for 0.010 in. Surface finish is ground to 10 microin., and shafts are passivated. All standard items from stock. Prices range from 62¢ to 90¢ each for lengths under 4 in.; $1.75 for lengths of 4 in. and over. **MCO Industries Inc, PO Box 1711, Rochester 11, NY.**

Circle 301 on Reader Service Card

Silicone and epoxy-silicone . . .

rubber combinations are room-temperature vulcanizing. The silicone formulation's weight is said to be roughly ½ that of comparable commercially available materials. Epoxy-silicone compound has good adhesive properties and retains flexibility after heat aging for prolonged periods to 450 F. Other materials available for service up to 600 F. Introductory kits, at $10, from stock. **Emerson & Cuming, 869 Washington St, Canton, Mass.**

Circle 302 on Reader Service Card

Fhp-motor brushes . . .

are externally removable for ease of maintenance. Series motors are intended for low-cost application to appliances and light-duty industrial equipment. About $5 in production quantities. Delivery, 5 wk. **Redmond Co Inc, Owosso, Mich.**

Circle 303 on Reader Service Card

Ultrahigh-strength steel . . .

is vacuum-induction melted for applications requiring high-working stresses, such as railroad car springs, valve springs and torsion bars. Carbides are said to be well distributed throughout matrix with no evidence of segregation. **Metals Div, Kelsey-Hayes Co, New Hartford, NY.**

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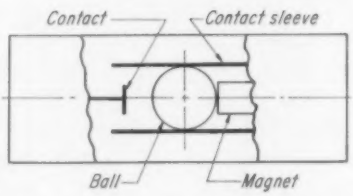


Miniature inertia switch . . .

is preset to respond in 0.015 sec to acceleration forces from 1 to 25 g within tolerance of ±5% of setting. Precision-ground steel ball is held against solid base by uniform magnetic field. When opposing force of acceleration exceeds magnetic force, ball moves to close normally open electrical contact. Said to meet environmental speci-

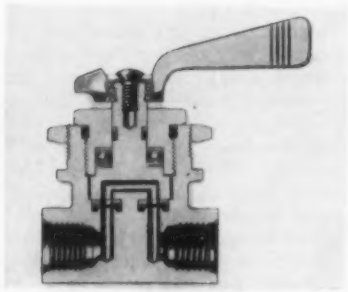
fications of MIL-E-5272, including operation in —65 to 200 F. Switch can be utilized for control or limiting applications when actuated by acceleration, deceleration, impact and/or shock. **Inertia Switch Inc, 311 W 43rd St, New York 36.**

Circle 305 on Reader Service Card

Thermoformed plastic cushioning . . .

absorbs shock, motion and vibration continuously. 1000 thermoformed cylinders per sq ft each act as an independent, resilient spring. Noncellular material is said to be dustproof, nonabrasive, noncorrosive and will not absorb moisture. Compression set, after packing and in transit, is said to be as much as ¾ less than other cushioning materials. Said to perform over temperature range of —80 to 215 F, to permit heat sealing, and to have high tensile strength. Also reported to be chemically resistant to acids, alkalis and organic solvents. **Preservation Packaging Inc, 1407 Chestnut Ave, Hillside, NJ.**

Circle 306 on Reader Service Card



Miniature selector valve . . .

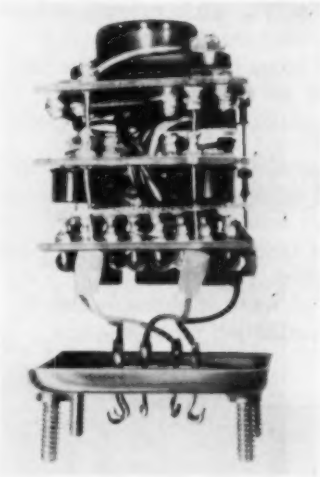
for 3000-psi pneumatic and hydraulic service measures 2 x 2 in. Valve for directional flow has microfinish sliding seals, which are wear-compensating. Line pressure aids sealing. Max panel thickness is 5/16 in. Body is forged aluminum alloy, with stainless steel internal parts. New handle is said to offer better panel clearance, increased handhold and leverage. Available in two-, three- and four-way models, sizes ⅛ and ¼ in. internal straight-thread gasket seal and internal pipe-thread connections. **Republic Mfg Co, 15655 Brookpark Rd, Cleveland 35.**

Circle 307 on Reader Service Card

Explosionproof 250 in.-oz synchronous motor . . .

for operation in hazardous areas is UL-approved for Class 1, Group D service. Withstands internal gas and vapor explosions and prevents ignition of surrounding external gas and vapor by internal spark, flash or explosion. Can be started, stopped or reversed instantly with single-pole, three-position switch. One revolution of motor shaft can be converted into 200 steps by applying dc voltage to field windings. Input is 120 v, 40/70 cps, single-phase, 0.6 amp max current at 60 cps. Output speed is 72 rpm at 60 cps. Weighs 7¾ lb. Planetary-gear type is available for applications that require torque of 650 in.-oz and speed of 16.6 rpm. **Superior Electric Co, Dept SS, Bristol, Conn.**

Circle 308 on Reader Service Card



Modular-built static relay . . .

has stacked or layered construction which permits design modifications. Relay is reported to offer operating life of 1 million cycles min; operate time of approximately 10 microsec, release time of about 50 microsec; no contact bounce; contacts isolated from control circuit; snap-action switching with varying input voltage, and resistance to shock of 100 g and vibration of 30 g to 2000 cps. For ambient temperatures of —67 to 159.8 F. Max operating current at operating voltage (30 v dc max) is 60 milliamp. Weighs 10 oz. **Controls Div, Leach Corp, 5915 Avalon Blvd, Los Angeles 3.**

Circle 309 on Reader Service Card

Precipitation-hardened alloy

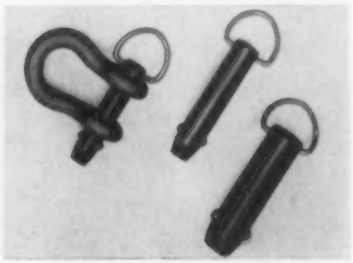
is vacuum-induction-melted nickel-base alloy for applications requiring relatively high stresses at intermediate temperatures of 1000 to 1500 F. Can be machined using high-speed cobalt cutting tools with slow speeds and heavy feeds. Can be welded by standard inert-gas tungsten-arc processes using filler wire of same alloy. Sheet is said to be formed easily in annealed condition and to have 0.2% yield strength of about 45,000 psi and ultimate tensile strength of 100,000 psi. Hardened by aging, room temperature yield strength is 110,000 psi and ultimate tensile strength is 160,000 psi. **Metals Div, Kelsey-Hayes Co, Middle Settlement Rd, New Hartford, NY.**

Circle 310 on Reader Service Card

Tank gaging of problem liquids

such as low-viscosity materials requiring heating for handling, liquids under pressure, volatile fluids, is now said to be possible with mercury instrument operating on purge-bubbler principle (pressure at exhaust of bubbler line at bottom of tank equals head pressure of liquid measured, and is then converted to in. of mercury with readout in appropriate direct units. Only material in contact with media measured is tube extending to bottom of tank and bubbling gas, generally dry nitrogen). Reported to provide characteristic accuracy of at least one part in 10,000. Installations are temperature compensated to correct for ambient temperature variations in region of manometer. Output data is generally in logical units, such as barrels, cubic feet or feet of depth to five significant figures. Type generally employed is of 32-in. range and can be located remote from measured vessel with bubbler line leading to vessel. Base price for stock instrument is $1930. Complete representative system is about $2400. About 3 wk delivery for system. **Exactel Instrument Co, 185 Evelyn Ave, Mountain View, Calif.**

Circle 311 on Reader Service Card



Quick-release pins . . .

are said to eliminate cotter pins and locknuts without increased costs. Designed with extra-large, stainless steel lockbuttons, pins are activated by silicone rubber, which will hold against vibration even in oversized holes. Alignment is facilitated by solid tapered end. Available in sizes from ¼ in. and up in stainless steel, naval bronze, or plated steel. Can be used as clevis pins, as chain and anchor shackle pins, safety-lock pins or shear-load pins, or wherever a quick-connect and disconnect pin is required. **Waldick Engineering Co, PO Box 398 Huntington Sta, NY.**

Circle 312 on Reader Service Card

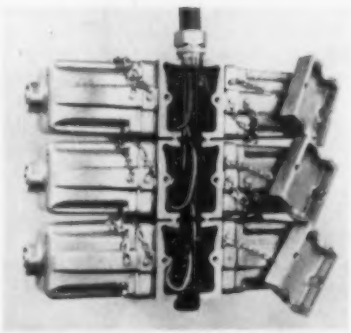
Elapsed-time indicator . . .

presents readout in direct-reading numerals about the size of typewriter characters (0.080 x 0.040 in. wide). Incorporates 50-rpm tell-tale disk and integrates 1000 hr

continued on page 68

in 0.1-hr increments or 10,000 hr in 1-hr increments. Weight, including hermetically sealed casing, is 1.6 oz; size is 0.680 in dia x 1.730 in. Withstands temperature variation from −65 to 165 F, 20 g vibration over 100 to 2000-cps range and 15 g, 11 ms shock; 115 or 26-v, 400-cps units drawing 1 w max at 0.018 amp are available for testing or application. **Elgin Micronics, Div of Elgin National Watch Co, 366 Bluff City Blvd, Elgin, Ill.**

Circle 313 on Reader Service Card



⅜-in. valves for manifold . . . mounting are available as single- or double-solenoid, spring-return types, two-, three- or four-way operation, two- or three-position, for air, vacuum and all conventional hydraulic fluids. Seven spool types are available. Direct-acting solenoid valves mount on $2\frac{3}{8}$-in. centers and up to five valves can be mounted on a manifold. Valves are equipped with built-in electrical junction box. Solenoids are industrial, constant-duty type and are equipped with manual actuators. Both solenoid and junction box covers are chained to valve body. Offered furnished with standard equipment or to JIC standards. **Beckett-Harcum Co, Wilmington, Ohio.**

Circle 314 on Reader Service Card

Heavy-duty directional valves for 2000-psi service in 20-, 30- and 40-gpm capacities are built in single- and multiple-valve units for mobile equipment applications. Offer differential pressure relief valves capable of bypassing full line capacities, ample cross-sectional areas and minimum of directional changes with smooth internal surfaces, and internal load check. **Century Engineering Co, Waukesha, Wis.**

Circle 315 on Reader Service Card

400-position rotary switches utilize removable wafers. Switching is transferred from one wafer to next through geneva gear control unit and associated control wafer. Any standard multiposition

continued on page 72

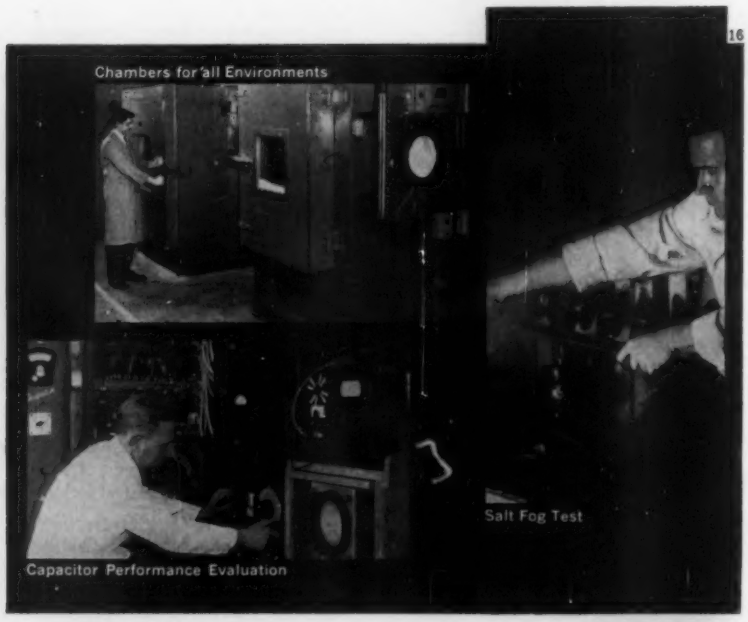
How United States Testing Company helps

SELECT THE BEST COMPONENT FOR YOUR PRODUCT

Trouble-free performance of a missile control demanded a power unit that would take severe environments and a heavy duty cycle. The control manufacturer's tight schedule and overloaded testing laboratory led him to call in United States Testing Company.

Our engineers set up an evaluation program to "lock in" with his tight schedule... tested each competing power unit in environments of heat, cold, vibration, and acceleration ...and submitted a "performance profile" for the best one... ahead of schedule... and within his budget.

Our complete evaluation facilities ...and engineers who knew where a product would "give" first... spelled quick testing service... high reliability... and low cost.
Why not write or phone us about *your* evaluation problem.



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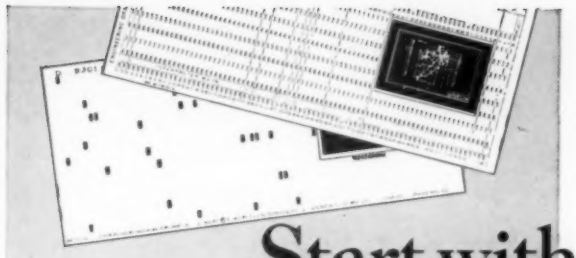
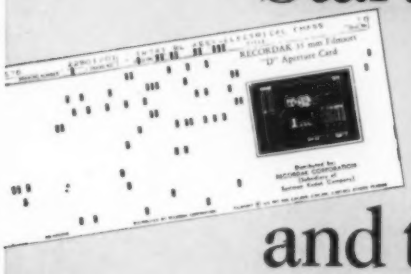
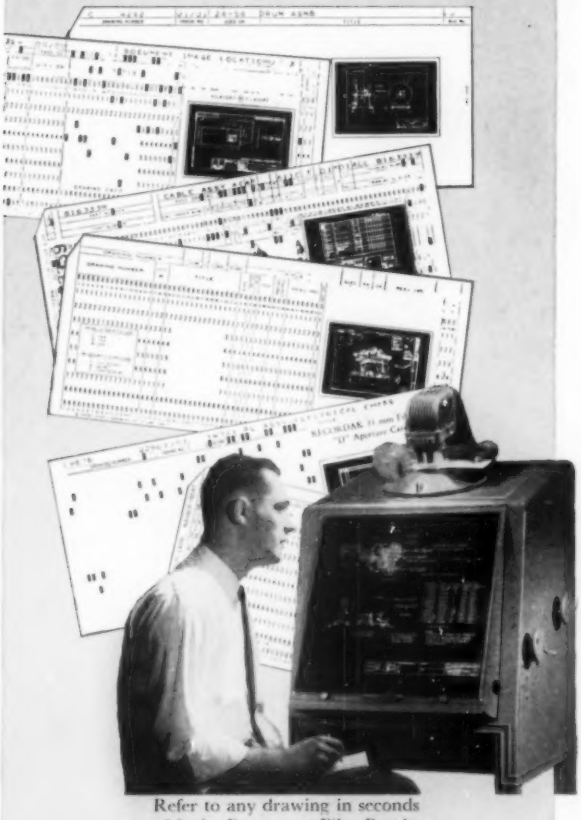


Start with the best pictures



and the rest is easy!

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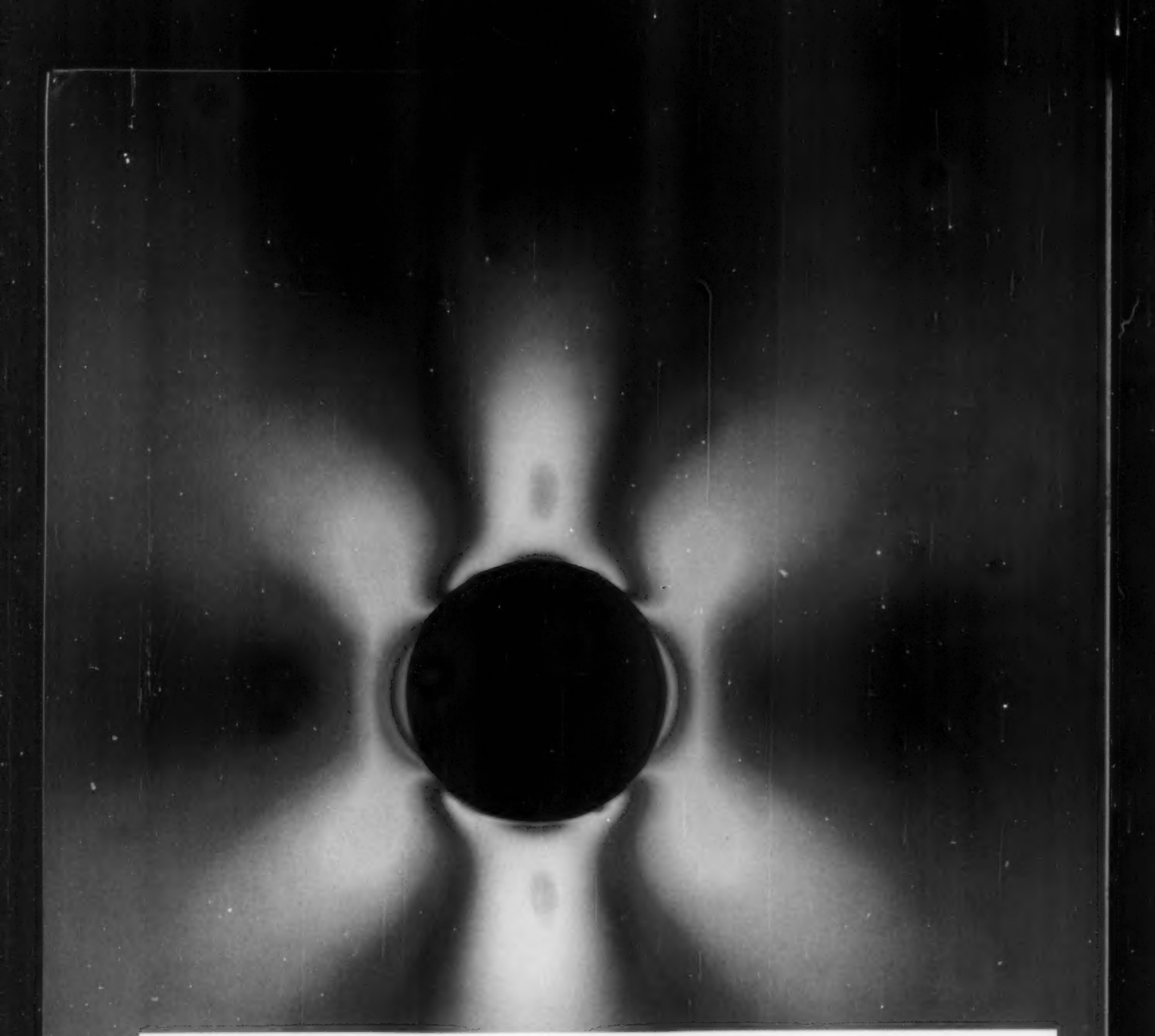


Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

For Greatest Strength Per Dollar... Use Malleable

To improve quality and cut costs, you'll find nothing better than Malleable iron castings. They provide more strength per dollar than any other metal, ferrous or non-ferrous! With Malleable you also get proven toughness, uniform quality and unsurpassed machinability.

See for yourself how much Malleable castings will improve your products and cut your costs. Send drawings or an outline of your requirements to a nearby Malleable castings producer who displays this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

For detailed information on "Strength Characteristics of Malleable Iron Castings", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

"Value Analysis" Proves–
Malleable Castings Improve Quality, Reduce Costs

When "Value Analysis" is your task, consider these outstanding advantages of Malleable iron castings: more strength per dollar than any other metal, ferrous or non-ferrous; exceptional machinability; metal exactly and only where it is needed; job-proven toughness.

Wide Range of Desirable Properties Available in Malleable

Standard and pearlitic Malleable irons are available with strengths ranging from 50,000 p.s.i. to 120,000 p.s.i. tensile.

Note in this table the high ratio of yield strengths to tensile strengths — especially important to you because yield strength is generally the measure of useable strength.

TENSILE PROPERTIES—A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Yield as a Percent of Tensile
Standard			
35018	53,000	35,000	66
32510	50,000	32,500	65
Pearlitic			
45010	65,000	45,000	69
45007	68,000	45,000	66
48004	70,000	48,000	69
50007	75,000	50,000	67
53004	80,000	53,000	66
60003	80,000	60,000	75
80002	100,000	80,000	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties

	Standard	Pearlitic
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000 — 28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40 — 0.50
Shear Strength — % of Tensile Strength	80 — 90%	70 — 85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

Switch to Malleable Saves 47% on Railroad Car Thrust Collar

One of countless examples of cost reduction obtained by changing from other materials or processes to Malleable castings is this thrust collar used on railroad maintenance cars. While the steel part formerly used performed satisfactorily, it cost 99¢ before machining.

The cost of the standard Malleable casting before machining is only 51.7¢ — a saving of 47.3¢! Added to this, four machining operations — drilling of bolt hole, spot facing for bolt head and nut, milling the sleeve slot and sawing the transverse slot — were eliminated by switching to a casting. All remaining machining operations are improved due to Malleable's exceptional machinability.

Former part before machining (99¢)

Malleable casting before machining (51.7¢)

Cost-Saving Engineering Assistance Available

The kind of engineering assistance that cut costs and improved product quality for these companies and thousands of others is available to you from any of the progressive producers of Malleable castings that are members of the Malleable Castings Council. Start increasing your product profitability right now — contact any of the companies listed below.

Free Information Folder

Your copy of an informative folder, *Data Unit 110—Malleable Castings in the Value Analysis Spotlight*, is available free from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, or from any member company.

For Quality and Economy...Use MALLEABLE

For Service In Your Area Contact...

CONNECTICUT

Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE

Eastern Malleable Iron Co., Wilmington 99

ILLINOIS

Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA

Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA

Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS

Belcher Malleable Iron Co., Easton

MICHIGAN

Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA

Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI

Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE

Laconia Malleable Iron Co., Laconia

NEW YORK

Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO

American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA

Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS

Texas Foundries, Inc., Lufkin

WEST VIRGINIA

West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN

Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

CIRCLE 71 ON READER SERVICE CARD

3 WAYS BETTER

ALBION'S NEW SERIES 16 CASTERS

Another completely new . . . completely practical Albion industrial caster series developed to serve a broader variety of applications. Conservatively rated as **medium duty** casters, yet constructed for longer, better . . . heavy duty, maintenance-free service. They're three ways better, and here's why:

1. MORE CAPACITY

The new Series 16 Casters offer Albion's finest, most dependable construction advantages such as "cold-formed" steel yoke base and top plate with heat-treated raceways for smoother, lasting maneuverability under greater capacity loadings.

2. MORE WEARABILITY

Albion's Series 16 Casters are available in nine different high capacity or floor protective wheel types in diameters of 3¼" to 8" with a capacity range of 140 to 900 lbs. per wheel. Sound engineering, quality materials and craftsmanship plus Albion's many outstanding construction features are combined to afford a caster that will last and last and last.

3. LESS COST

Although built to Albion's exacting quality standards, the Series 16 cost you far less than most ordinary casters of the same size or capacity ratings. And . . . they are available—all models—right now!

RIGID CASTERS
Albion's Series 16 Casters are available as matching rigid models in 9 wheel types—3¼" to 8" wheel diameters.

Remember . . . if you want longer, better service plus caster versatility at a savings you can count —be sure to get all the facts and figures from Albion.

Write—wire or phone today for your copy of the new illustrated specification sheets on Albion Series 16 Casters.

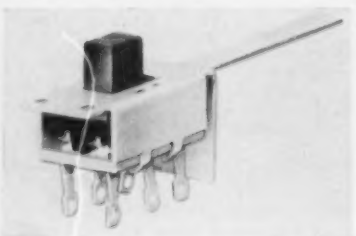
ALBION INDUSTRIES, INC.
Albion Michigan

indicating dial can be furnished. Switches have positive indexing with manual, motor or solenoid drive. Wafers are available in standard XXXP with solver-plated etched circuitry or in epoxy glass with nickel-rhodium or gold-plated circuitry. Components can be included in wafers. Also offered are switches that handle up to 100 positions. Price varies with number of positions and switch size. Delivery, 30 to 60 days. **Chicago Dynamic Industries Inc, Precision Products Div, 1725 Diversey Blvd, Chicago 14.**

Circle 316 on Reader Service Card

Removable contacts . . . in crimp and solder types for wide variety of wire sizes are said to achieve higher contact retention in all applications and lower millivolt drop. Socket contacts are machined from electrical grade A phosphor bronze; pin contacts are machined from high-conductivity commercial bronze. Both have hard gold alloy plating over silver. Available for immediate delivery. Supplied separately to be assembled by user into connector body molding. **General Products Corp, Union Springs, NY.**

Circle 317 on Reader Service Card



Extension-plunger switches . . . are said to be particularly suited for use where conventional panel mounting is not convenient. Available as DPDT switch with detent rated at 0.5 amp, 125 v ac or dc; as SPST, SPDT or DPST switches with detent and SPST or SPDT switches with spring return in ratings from 0.5 amp at 125 v ac or dc up to 4 amp at 125 v ac. Available for immediate delivery. **Continental-Wirt Electronics Corp, 26 W Queen Lane, Philadelphia 44.**

Circle 318 on Reader Service Card

Vibration isolator . . . is for applications where horizontal thrust is not severe and is offered in load capacities from 25 to 15,600 lb per mounting in

continued on page 75

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It's the difference that lets you combine *high-reduction* with strength, compactness and other advantages you might find profitable in certain applications. For instance . . .

For smooth operation—as in office equipment that must run quietly—high-offset pairs provide smooth, quiet tooth action. Because the teeth "wrap around" the pinion, *you get continuous action—even with just one or two teeth.*

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PHOTO BY HAROLD M. LAMBERT

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- **Cleaned from OUTSIDE the TANK—No Valves required**
- **SUCTION or RETURN Lines**
- **FILTRATION to 10 MICRONS**
- **NO FLUID LOSS**
  Except that contained in Filter

SEE IT CLEANED IN 5 MINUTES

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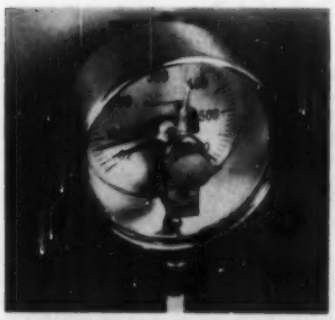
four types. Isolates vibration caused by machinery with operating speeds and disturbing frequencies of 350 cpm and higher, with average static deflection of 1 in. Bolting equipment to floor is eliminated by use of nonskid, corrugated neoprene pads bonded to mounting baseplate. Available for immediate delivery. **Vibration Mountings Inc, 98-15 50th Ave, Corona 68, NY.**

Circle 319 on Reader Service Card

Unplasticized PVC ball valve . . .
is produced by molding process said to achieve ball valves that are dimensionally stable with high impact strength. Compound is reported to meet proposed new ASTM specification, to have tensile strength of 8500 psi, to be nontoxic, nonflammable and almost completely nonaging. Can be heat welded or solvent bonded. For service to 140 F. Valves have been rated at 125 psi. With Teflon seat. Positive stops indicate full open and full closed positions. Initially offered in ½-, ¾- and 1-in. sizes, all NPT female connections. **Hoke Inc, 1 Tenakill Park, Cresskill, NJ.**

Circle 320 on Reader Service Card



Bimetal dial thermometers . . .
for temperature measurement on ferrous materials are magnetically attached. Available in three styles for temperature measurement only; with max reset hand, and with electric contactor to permit on-off temperature control with electric resistance or induction heating. Offered in temper-

continued on page 79

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New manufacturing methods also make possible a more nearly perfect concentricity of the unit's diameter. This means closer fit at the installation, and a more effective use of the greater heat created by the new FIREROD.

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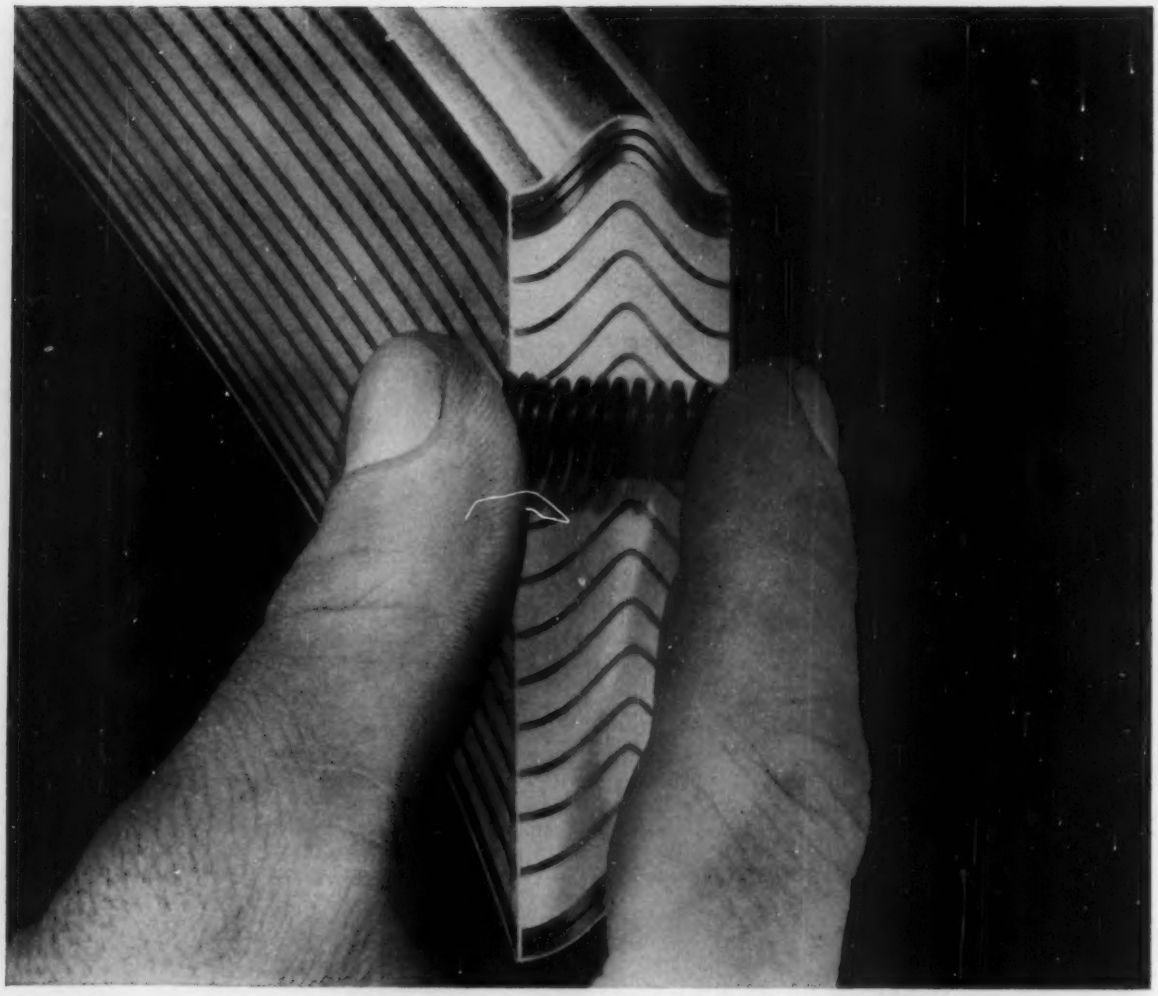
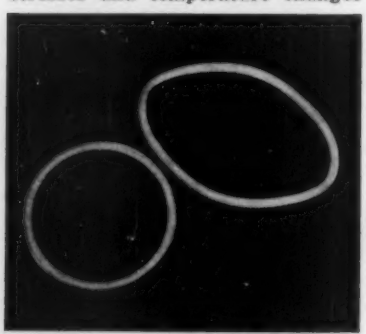
1392 Ferguson Avenue
St. Louis 14, Mo.



"Spring Action" gives you a leakproof seal with J-M SPIROTALLIC® GASKETS

Johns-Manville makes a specialty of building a lively "spring action" into Spirotallic Gaskets. Because of their superior resiliency, Spirotallic Gaskets can compensate for varying stresses and temperature changes ... follow minor flange separation ... and absorb vibration. Even under these difficult circumstances, they keep a tight, durable seal.



Oval and round shapes spirally wound

This quick adaptability has given Spirotallic Gaskets a tremendous popularity in the field. Their springiness is due to the special methods and control J-M uses in their manufacture. Spring-like metal strips, formed into a special vee shape, are alternately spiral-wound with an asbestos filler. The filler does the sealing . . . and the vee shape provides the "spring."

Another reason for the widespread acceptance of Spirotallic Gaskets is the fact that when the gasket has been compressed the proper amount, it reaches optimum performance for the bolting. Many different metals and fillers can be used. Each metal is color-coded to aid maintenance personnel in quick identification of the type of metal used.

J-M produces a wide variety of sizes and shapes for standard flanges. And for special flanges, J-M will design and produce a gasket with the precise characteristics you require. For complete information, ask for J-M catalog PK-35A. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

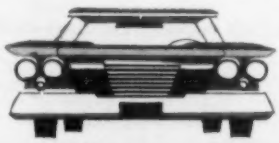
CIRCLE 77 ON READER SERVICE CARD →

Better products through better methods and steels

How zinc-coated steel cut 5 steps from automotive lamp housing fabrication.

When automotive head and tail lamp housings were drawn from cold rolled sheet steel and then zinc-plated or painted, as many as five or six handling and cleaning steps were required to make them corrosion-resistant.

Now, fabricated from Weirkote continuous-process zinc-coated steel, the housings go directly from the press to the assembly line. Further processing is unnecessary because Weirkote can be worked to the limits of the steel itself without chipping or flaking its corrosion-resistant zinc surface.



It's this superiority that caused the automobile industry to increase its consumption of zinc-coated steel more than 700% in five years; to use it in such varied applications as mufflers, window channels and the understructures of unitized bodies; to take advantage of developments such as differentially zinc-coated steel that can be welded at top production-line speeds.

A major supplier is Weirton Steel Company—producer of Weirkote continuous-process zinc-coated steel sheets and many other excellent steels that are improving products, methods and profits throughout industry.

Galvanized Steel

Look for the STEELMARK on the products you buy; place it on the products you sell.

WEIRTON STEEL
Weirton, West Virginia

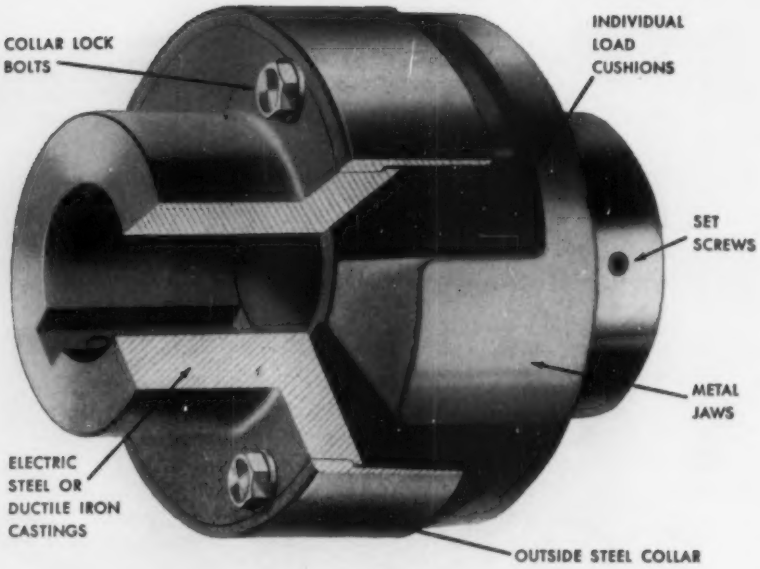
WEIRTON STEEL COMPANY

Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

Weirkote will also be available in 1961 from National's Midwest Steel Division, Portage, Indiana.

A Report To Equipment Manufacturers

LOVEJOY TYPES C and H FLEXIBLE COUPLINGS UP TO 4250 hp.



Installed and Aligned In Minutes

Just slide on the shaft, bring the jaws together and insert cushions. A twist of the bolts on the outside collar firmly retains the visible cushions.

Alignment is equally simple. Just use a straight edge. Gauges are not required.

Eliminate Trouble and Service Calls

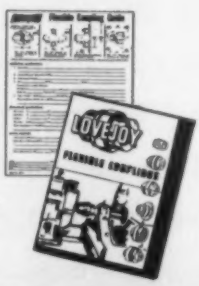
Lovejoy Flexible Couplings contain no intricate parts or mechanisms that require attention or can cause possible trouble. All parts, including cushions, are in plain sight for rapid inspection. Lubrication is never required. Water, oil, dirt or weather will not harm or in any way decrease efficiency.

The best care for Lovejoy Couplings is to *put 'em on shafts and let 'em alone.*

Outlast Equipment Life

Bodies are carefully machined from electric steel or ductile iron castings. The load is entirely transmitted by cushion compression, eliminating metal-to-metal contact and resultant wear on metal parts and jaws.

Even the cushions last longer. First, they are furnished in the material best suited to the service. Second, on non-reversing loads, their life can be doubled simply by reversing or advancing.



Lovejoy Flexible Couplings can be delivered immediately from stock. Heavy-Duty Types C and H run from 18 to 4250 hp. at 1200 rpm. in a wide range of bore sizes. Other sizes and types run from .05 at 100 rpm. to 1020 hp. at 1600 rpm. to provide the most complete selection of couplings available to industry.

Request full information and ask for Catalog C-58. Give details or specifications for prompt quotation.

Lovejoy

FIRST NAME IN FLEXIBLE COUPLINGS

LOVEJOY FLEXIBLE COUPLING COMPANY

4841 W. LAKE STREET, CHICAGO 44, ILLINOIS

Telephone ESlebrook 9-3010 • Teletype TWX-CG-85

SALES OFFICES THROUGHOUT THE CONTINENT

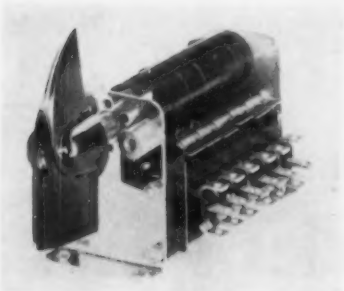
ature ranges from −60 to 700 F and are said to have accuracies of better than 2%. Industrial Service Co, 2 Richmond St, Providence 3, RI.

Circle 321 on Reader Service Card

Brake motor is up to 6 in. shorter . . .

and said to be as much as 20 lb lighter than standard brake-motor designs of equivalent ratings. Frame and endshields of brake motor are rigid cast iron. Initially offered in dripproof construction only in polyphase ratings of 1 through 5 hp at 1800 rpm, ¾ through 3 hp at 1200 rpm and ½ through 2 hp at 900 rpm. General Electric Co, Schenectady 5.

Circle 322 on Reader Service Card



Rotary selector switch . . .

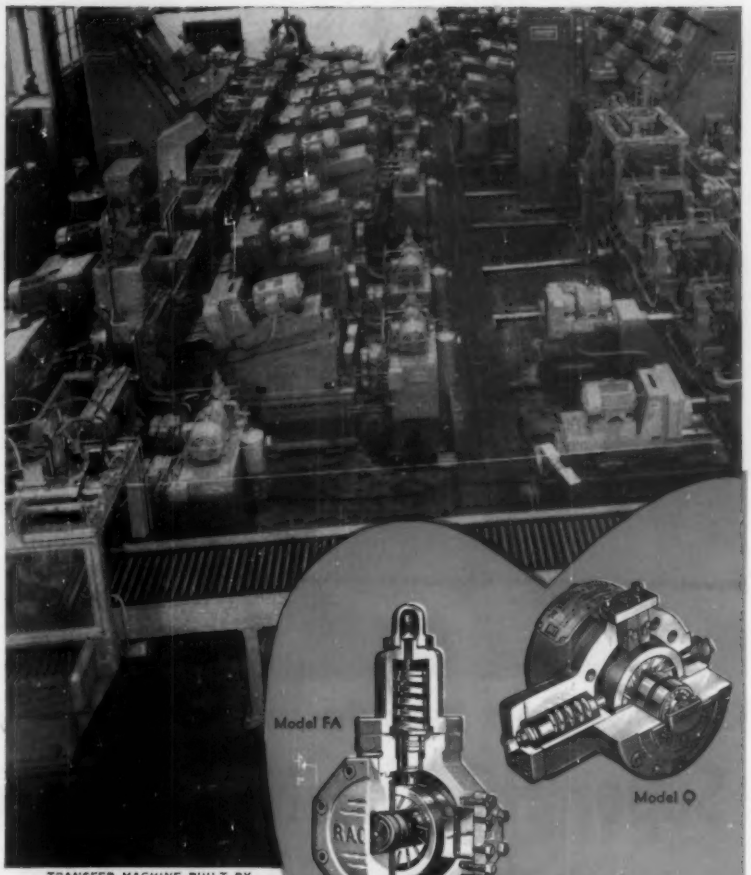
in 4-pole and 6-pole models is (for each switch or pole) UL-approved at 12 amp, 125 v ac or 6 amp, 250 v ac. Circuits are double or single throw, normally open or closed. Each switch cam is adjustable to six positions in increments of 60°. Switch is either on or off during complete cycle; 46,656 permutations or switching possibilities available in six-position switch. Rotation can be automatic or manual, clockwise or counterclockwise. Mechanical stop is provided after 300° rotation, or can be rotated continuously through 360°. For surface mounting or through panel holes. Available with standard knobs. Columbus Electric Mfg Co, 2005 E Main, Columbus 5, Ohio.

Circle 323 on Reader Service Card

Electronic-alarm flowmeter . . .

measures fluid rate of flow and indicates abnormal high or low flows by electronic detection. Instruments employ standard flowmeter with 5 in., 10 in. or 600 mm tube and high-frequency pickup sensing coil mounted flush against metering tube. Coil is adjustable over full range of scale and is connected by cable to electronic alarm. Can activate warning light or alarm device and will start or stop a pump, motor or control unit. Available in model requir-

continued on page 81



TRANSFER MACHINE BUILT BY BUHR MACHINE TOOL CO., ANN ARBOR, MICHIGAN

Automated GIANTS like this

REQUIRE STRONG HYDRAULIC *HEARTS* EVERY MINUTE OF THEIR WORKING LIFE

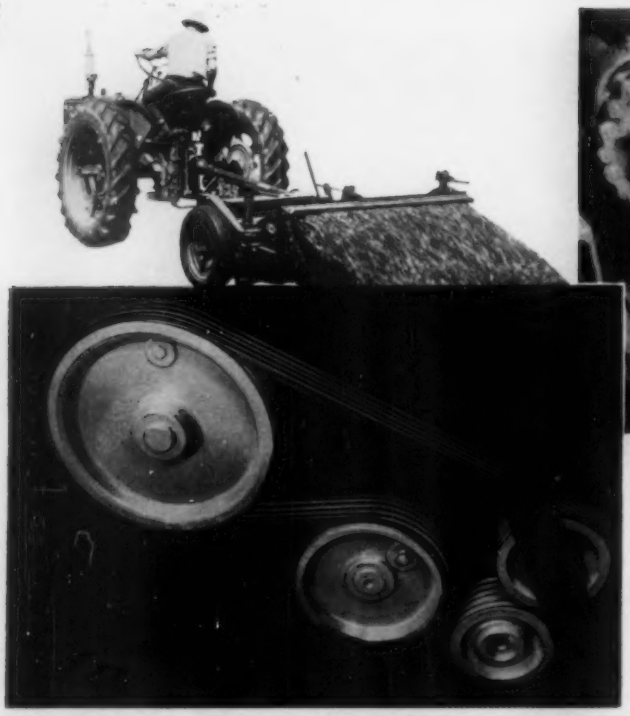
24 RACINE PUMPS *operate this 58 station 500-ton transfer machine*

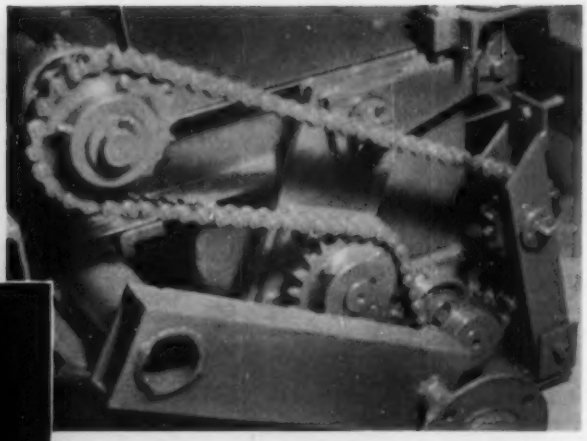
The precisioned flow control of RACINE PUMPS assures the split-second timing and efficiency required to operate this complex Buhr Transfer Machine . . . custom-built for the completely automatic machining of 120 auto-cylinder heads hourly for a leading automotive manufacturer. Compact RACINE VALVES control feeds and reverse movements on all 323 operations performed by the machine. RACINE 4-WAY SOLENOIDS help one man operate this mechanical giant. Buhr has used RACINE PUMPS and Reservoir Units on custom-built machines for the automotive industry for over 10 years.

RACINE

Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

CIRCLE 79 ON READER SERVICE CARD





FORMER DRIVE: The high speed operation of Gehl's Cure-All Hay Conditioner caused failure of the roller chain drive.

PRESENT DRIVE: Both the limited space and high speed requirements were met with this Gates Super HC V-Belt Drive.

Gehl Brothers Manufacturing Company Finds

Super HC V-Belt Drive handles speeds chain drive couldn't take!

Roller chain drives on Gehl's Cure-All Hay Conditioners **"would not stand up under the speed of operation." Yet conventional V-belts that would fit into the space available could not handle the working load for this outstanding line of forage harvesting equipment.**

The design problem remained a tough one until the introduction of the Gates Super HC High Capacity V-Belt early last year. Then the Gates Field Engineer, working closely with Gehl Engineers designed the new drive shown above.

"The Super HC V-Belt Drive has eliminated need for shear pins and clutches, has increased efficiency, and lowered maintenance costs," is the pleased report from Gehl personnel.

Take advantage of Super HC on your equipment

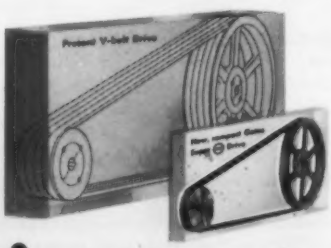
Whenever you have a drive change on a new model or are replacing belts or sheaves, let your Gates Representative show you how Super HC Drives can reduce sheave diameters 30% to 50%, drive space up to 50%, drive weight and cost as much as 20%.

A handbook, "The Modern Way to Design Multiple V-Belt Drives," is yours for the asking. Simply contact your Gates Representative listed in the Yellow Pages.

TPA 505

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates *World's Largest Maker of V-Belts*



Gates Super HC V-Belt Drives

same hp capacity in smaller "package"

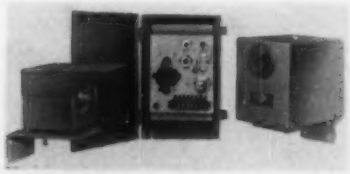
ing manual reset, which can be used with two sensing coils for high and low alarm settings and in model with automatic reset, which is used with one coil to detect deviations above and below desired flow conditions. **Schutte & Koerting Co, Instrument Div, Dept M-T, Cornwells Heights, Bucks Country, Penna.**

Circle 324 on Reader Service Card

Solid urethanes . . .

can be compounded to customer specifications in roll, sheet, tube, rod and cast parts for industrial applications. Properties such as high tensile strength, resilience, abrasion resistance, elasticity, superior hardness, rigidity, load carrying, oil resistance, oxygen and ozone resistance can be combined in varying degrees to satisfy individual needs and on reproducible basis. **Armstrong Cork Co, Industrial Div, Lancaster, Penna.**

Circle 325 on Reader Service Card



Heavy-duty photoelectric relay

in two types, for operation at up to 2000 ft and for use under 100 ft, is suitable for use in atmospheres dense with foreign matter and where extraneous light source could cause false operation in conventional unit. Modulated signal beam is said not to be affected by other light sources. Pulsed light signal has to be completely broken to operate relay. A 0.1-sec interruption of signal beam will operate either relay. Max operating rate is 600 operations per min. **Clark Controller Co, 1146 E 152nd St, Cleveland 10.**

Circle 326 on Reader Service Card

Bronze globe and check valves

have working pressures of 2500 psi cold water, oil or gas (water and oil ratings are nonshock). Features 45° seat (flat to flat). 1½ and 2 in. valves are furnished with bolted bonnets with O-ring gasket and have handwheels instead of lever handles. **Crane Co, Industrial Products Group, 155 N Wacker Dr, Chicago 6.**

Circle 327 on Reader Service Card

Reinforced-plastic shapes . . .

are available in one or more of five different fiberglass and resin combinations. Tensile strength ranges to 58,000 psi; compressive strength to 90,000 psi. Specific

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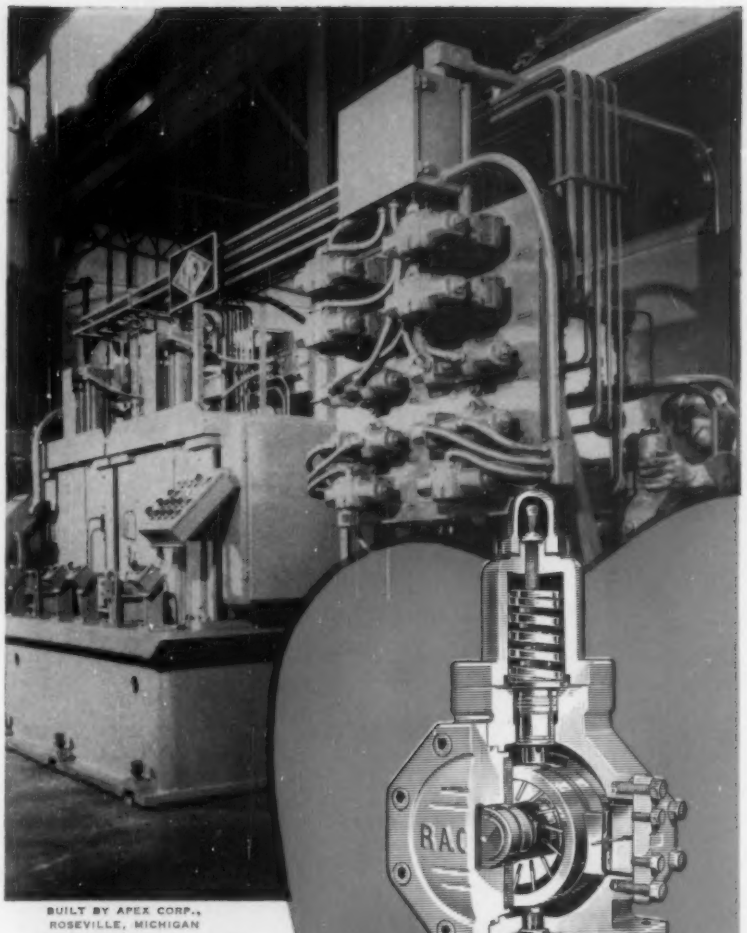


BUILT BY APEX CORP., ROSEVILLE, MICHIGAN

This active hydraulic heart helps

the HEART of this impregnating machine is a RACINE MODEL 6FA PUMP

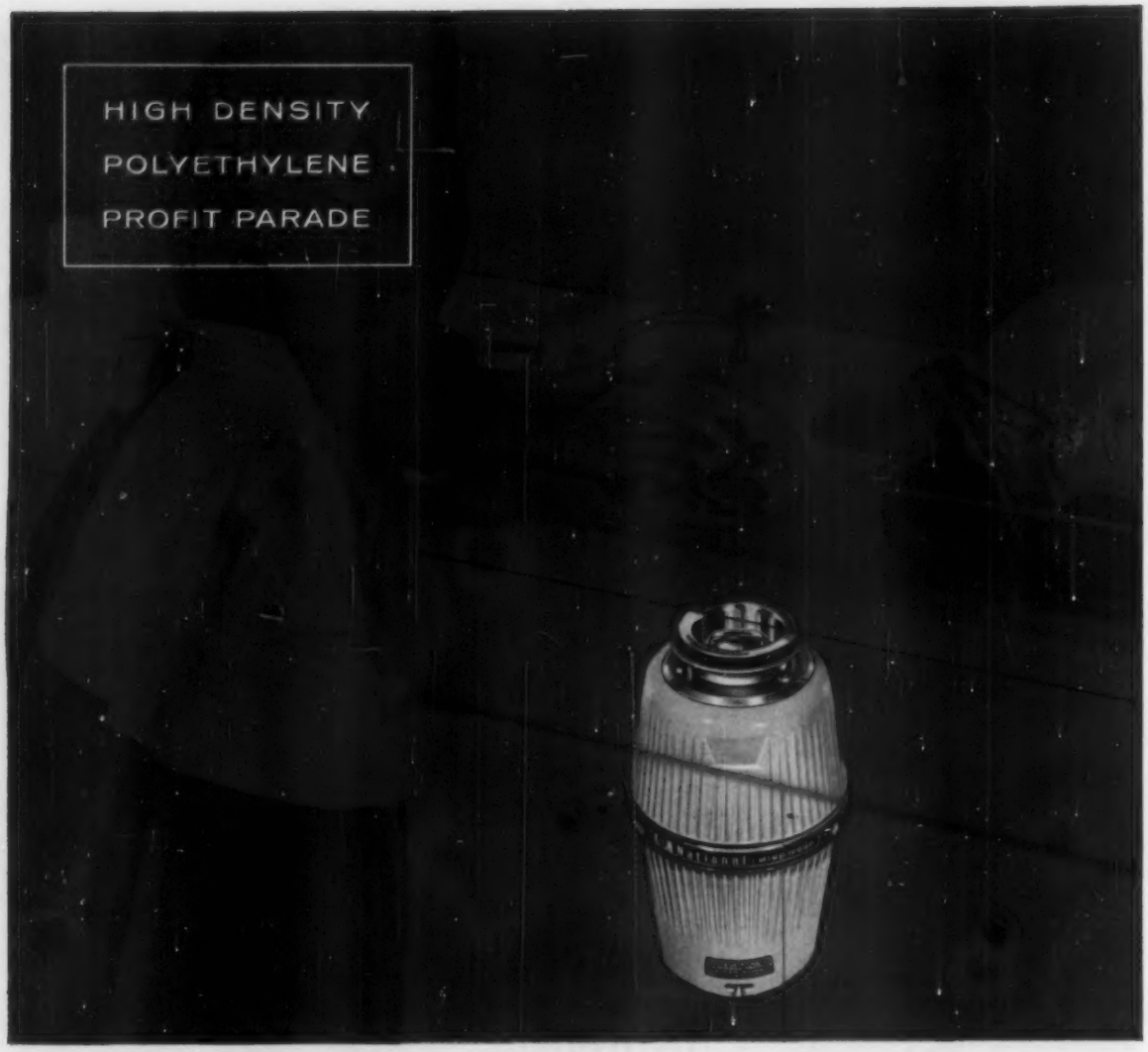
SEAL POROSITY IN 106 TRANSMISSION CASES EVERY HOUR

A RACINE VARIABLE VOLUME PUMP and 10 RACINE VALVES control *all* mechanical operations in this Apex impregnating machine, which seals leaky transmission cases at a major auto firm's transmission plant in Toledo, Ohio. Apex specified RACINE equipment because its design simplifies machine design problems . . . eliminates the need for extra pumps and valves. RACINE PUMPS are easy-to-control . . . handle pressure compensation *automatically* for varying gpm requirements. Apex has *preferred* RACINE for over 10 years!

RACINE

Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

CIRCLE 81 ON READER SERVICE CARD



Grace Plastic Upgrades New Appliance Model

The new Citation Model National Disposer shows how the use of Grex high density polyethylene results in upgrading a product to increase its consumer appeal.

Made by the Plumbing Equipment Division of National Rubber Machinery Company, the appliance grinds food wastes into micro-sized particles that wash down the drain. Its primary appeal is freedom from garbage-handling chores. Three additional sales-stimulating features are direct results of specifying Grex for the housing:

1. Freedom of design due to the moldability of the Grace plastic provides clean, fresh styling.

2. A choice of attractive colors is offered. Colors are molded into the Grex housing—can't peel, chip or fade.

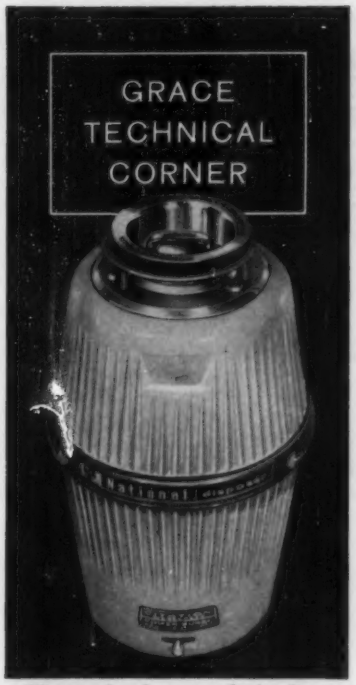
3. The plastic's sound-deadening properties are utilized to help make the Disposer operate "whisper quiet."

In addition to these features, the housing is strong, rigid and virtually indestructible. It cannot rust, is unaffected by chemicals normally corrosive to other materials and withstands the high temperature of boiling water.

If you are looking for ways to upgrade your product it will pay you to find out exactly what high density polyethylene has to offer by calling in the experts. Grace has the production, technical, and marketing facilities to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION CLIFTON, NEW JERSEY



What are the advantages of using Grex to make a product prototype?

The prototype for the new model National Food Waste Disposer shown here was vacuum formed from Grex sheet in our Clifton Laboratories. Whenever possible, prototypes of products designed for production with high density polyethylene should be made of the same material. This is the best way to see how the product will look and feel before costly molds are built and production actually started.

Helpful in marketing. Although most prototypes are required from an engineering standpoint they are often useful to guide marketing decisions as well. This was the case with the Grex prototype of the National Disposer. The object was to determine, in advance of production, how the trade would react to the new model by presenting prototypes or samples that come as close as possible to the finished product.

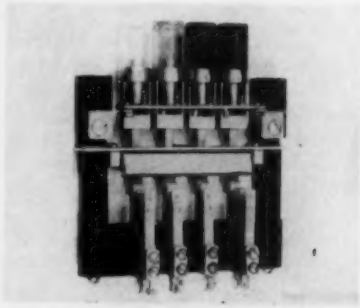
Grace's part. Working from the manufacturer's engineering drawings Grace designed wooden molds and vacuum formed a number of samples from Grex sheet. The samples were sent to the manufacturer for finishing (trimming of flash and drilling the necessary holes), and returned to Clifton for surface finishing. The samples were completed in time for display at an important trade show. Trade reaction was highly favorable, just as you would expect from reading about the product on the opposite page.

You are invited to take advantage of Grace technical service. Perhaps we can help you by making a Grex prototype for your high density polyethylene application. Or perhaps you need assistance on other aspects of design or production of high density polyethylene parts. If so, now is the time to contact:

Technical Service Department
W. R. Grace & Co., Clifton, New Jersey

volume is 118.7 lb per cu ft max. Angles are available in 73 leg sizes from ½ x ½ x 0.040 in. to 6½ x 6½ x 0.5 in. Structural shapes can be machined or drilled, riveted or bonded. Molded in color for identification purposes. **Commercial Products Div, Plastic Age Mfg Co, 14300 Davenport Rd, Mint Canyon, Calif.**

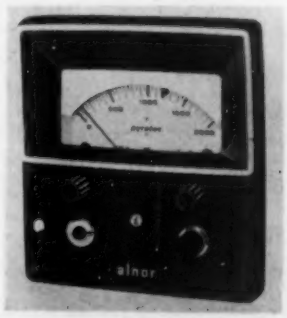
Circle 328 on Reader Service Card



Multiple pushbutton switches

in illuminated and nonilluminated types are available in two to 16 buttons per row, with momentary, locking or accumulative lock-button actions. Lock-out mechanism is available to prevent more than one button from being depressed at a time. Illuminated switch has printed circuit lamp strip with front-of-panel replacement of lamps. Max depth behind panel is 3 1/16 in. for illuminated model and 2⅜ in. for nonilluminated model. Button pressure is about 1 lb for single-pole switches and 1½ lb for three-pole switches. **Switching Controls Corp, 8222 Lankershim Blvd, N Hollywood, Calif.**

Circle 329 on Reader Service Card



Indicating temperature cutout

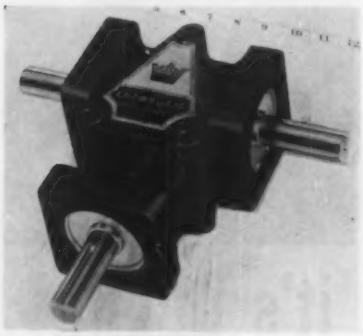
is offered in model that will not shut off upon line-voltage failure and model that will. In addition to cutout function, device can be used to sound alarm and/or light signal upon excess temperature condition. Can also be supplied as low-temperature cutout. Excess-temperature controller is available in 11 ranges from 0-400 to 0-3000 F, as well as an environmental test chamber range of —100 to —300 F. **Alnor Instrument Co, Div of Illinois Testing Laboratories Inc, 418 N LaSalle St, Chicago 10.**

Circle 330 on Reader Service Card

Direct-printed circuits . . .

are reproduced on ceramics and glass with circuit thickness between 0.0003 and 0.0010 in. In most instances, pattern tolerances can be held to ±0.002 in. Patterns can be applied on flats, tubes, rods, cones and other geometric shapes. Silver inks used for circuit reproduction are reported to obtain high bond strength, high scratch resistance, and heat stability to 1000 F. Volume resistivity is 5×10^{-4} ohm-cms, giving normal printed line resistivity of 0.004 per sq. **J Frank Motson Co, Flourtown, Penna.**

Circle 331 on Reader Service Card



Right-angle gear package . . .

delivers 8 hp at 1100 rpm. Construction is said to enable unit to stand up for long periods with little or no maintenance, even under continuous peak loads. Shaft dia is 1 in.; shaft extensions, 2¾ in. Housing measures 6½ x 8¼ x 4 in. Heavy-duty unit incorporates hardened spiral bevel gears, double sealed ballbearings and stainless steel shafts. Weighs 18 lb. **Crown Gear Div, Harrington & Richardson Inc, Worcester 10, Mass.**

Circle 332 on Reader Service Card

Strain-gage waterproofing . . .

compounds are offered in experimenter's kit. Included are flexible epoxy systems for room and medium temperature use and silicone coatings for service at temperatures to 600 F. **Strain Gage Accessories Co, PO Box 281, Northridge, Calif.**

Circle 333 on Reader Service Card

Templet for hex screw heads

and nuts in top and side views has range of ⅛ to ¾ in. as measured across the flats. Contains 12 hexagons, circles and chamfer crescents. Made of 0.030 matte-finish plastic, with over-all size of 8 x 2¾ in. Price, $1.50. **Rapidesign Inc, PO Box 429, Burbank, Calif.**

Circle 334 on Reader Service Card

it's DELRIN*

You get metal-like properties in these new, plastic, prevailing-torque lock nuts: excellent strength, rigidity and dimensional stability.

Recommended for light metal assemblies, toys and similar fastening . . . they can save about half the cost of aluminum lock nuts.

Available in #10 and ¼" sizes, the RB&W open end acorn nuts have holding strength of 500-700 lbs in straight tension. Prevailing torque (a measure of its locking) is 8-10 in-lbs for the #10; and 12-15 in-lbs for the ¼". The nut forms its own thread. Pigmented gray is standard; other colors available in production quantities. Reusable. Send for samples.

Ask about other sizes and styles . . . and other parts custom molded from Delrin or other thermoplastics in production lots.

Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*DuPont trademark

R B & W
116th year

DESIGN LITERATURE

The Mechanisms of Fatigue

J C GROSSKREUTZ & FRED R ROLLINS, Midwest Research Institute. (WADC Report 59-192). Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 64 pp. $2.

X-ray and electron microscope techniques show that scattered orientation of subgrains is the most pronounced structural change that shows up in fatigue. These grains form within the first 15% of the fatigue life and cannot be removed by subsequent annealing at high temperatures. This report on copper and aluminum in cyclic stressing also discusses why fatigue cracks originate.

Self-saturating Magnetic Amplifiers

LYNN, PULA, RINGELMAN, TIMMEL. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9, 217 pp. $8.

Here is a thorough treatment of self-saturating magnetic amplifiers. Facts on their operation, and precise, accurate design techniques show you how to design complex magnetic-amplifier circuits with a minimum of experimentation. The true operation of a physically realizable amplifier is explained in line with readily observable laboratory phenomena, and idealizations of nonlinear functions are made only after the real conditions are discussed.

Among the subjects covered are the basic assumptions involving circuital laws; modern techniques for dealing with the transient behavior of self-saturating magnetic amplifiers; transformer theory; feedback-control theory; and magnetic theory. In addition, there are facts on the design of magnetic amplifiers; testing methods applicable to magnetic-amplifier core material; a logical method for pursuing a design from application to finished amplifier; and a number of commonly encountered design problems.

The Electric Arc

J M SOMERVILLE. John Wiley & Sons Inc, 440 Park Ave South, New York 16. 4 x 6½, 150 pp. $2.50.

The book is for the nonspecialist, but is a complete, concise monograph on the electric arc, making clear the basic physical phenomena which operate when a large electric current passes through a gas (including air). Following a short introductory chapter, Part I of the book treats stable-arc discharge. Beginning with an account of the properties of the arc column and how they are measured, it discusses, among other topics, the nature of the energy transfer to and from the column, the use of the column as a source of light, and the possible production of thermonuclear reactions in high-temperature-arc columns. The complicated situations prevailing at the electrode-column junctions are then described, and, when no generally agreed interpretation exists, the author outlines the various competing theories. Part II describes the various approaches to the stable arc, particular attention being given to the approach via the spark.

Much of the material in the book has not previously been available in English. There are a large number of references, the majority cite recent work.

ABSTRACTS FROM THE LITERATURE

Effect of Strain on Tensile Properties

Describes research undertaken to determine more exactly the effect of strain rate on dynamic strength of certain materials and to extend the strain rate at which the strength had been measured. Materials included in the test program: cold-rolled steel, six aluminum alloys, uranium and lead.

"The Tensile Properties of Some Engineering Materials at Moderate Rates of Strain," Steidel and Makerov, Lawrence Radiation Laboratory. ASTM Bulletin, July '60. American Society for Testing Materials, 1916 Race St, Philadelphia 3.

Human Power Capacities and Limitations

Presents data for human power generation by crank and pedals. Also discusses such considerations as cranking through small radii, cranking through large radii, cranking vs control, strength potentials of various types of

continued on page 86

ORDER AFTER ORDER AFT
FTER ORDER AFTER ORDER
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ORDER AFTER ORDER AFT
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ER AFTER ORDER

Stainless Sheet...Exactly the Same Order After Order...From A-L

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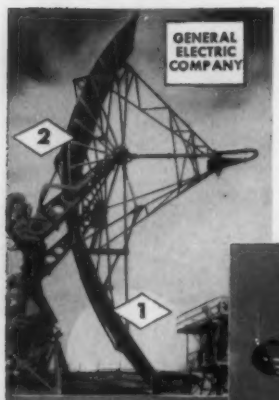

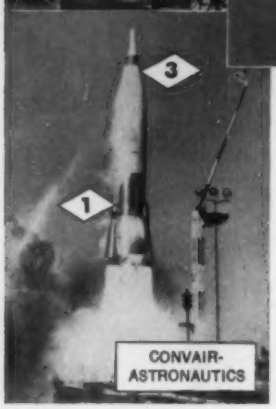

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hand motions, and some data (German) on pedal-developed power.

"Man-generated Power," E. S. Krendel, Franklin Institute Laboratories for Research and Development. Mechanical Engineering, July '60, 29 W 39th St, New York 18.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

SERVO COMPONENTS—Technical text, 56 pp. Sixth edition of text on construction, performance, application and testing of servomotors, motor generators, tachometer generators and synchros. Includes diagrams, charts, outlines, tables, schematics, definitions and formulas. Kearfott Div, General Precision Inc, Little Falls, NJ.

Circle 350 on Reader Service Card

AUTOMATION COMPONENTS AND CONTROL SYSTEMS—Condensed catalog D-31, 24 pp. Specifications and ratings of timers, counters and control units, and other automation components. Automatic Timing & Controls Inc, King of Prussia, Penna.

Circle 351 on Reader Service Card

MINIATURE PULSE TRANSFORMERS—Catalog, 20 pp. Revised, third edition covers design and usage of low-level pulse transformers. Discusses history, methods of measurement and theory of application. PCA Electronics Inc, 16799 Shoenborn St, Sepulveda, Calif.

Circle 352 on Reader Service Card

CASTERS—Catalog 12-A, 12 pp. Condensed and abridged version of Catalog 60, which illustrates complete line of casters and wheels. This covers specifications of popular casters plus several specialty models. Payson-Harris & Reed Inc, 2916 W Jackson Blvd, Chicago 12.

Circle 353 on Reader Service Card

PLASTIC CABLING AND CIRCUITRY—Bulletin S-9, 8 pp. Includes design features, specifications and applications for multiconductor flat wire cable, multilayer circuitry and flexible etched cable, circuits and laminates. International Resistance Co., 401 N Broad St, Philadelphia 8.

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MAGNETIC GAGES—Catalog 388, 6 pp. Covers features, models, construction and operation of liquid level gages for use where glass and its gaskets cannot be tolerated and where sealed container for liquid is preferable. Jerguson Gage & Valve Co, 80 Adams St, Burlington, Mass.

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continued on page 89

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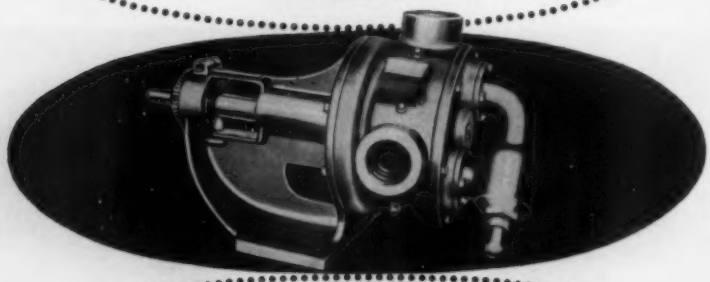

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Circle 356 on Reader Service Card

MOTOR-SELECTION GUIDE—Pocket-size card GED-3909A. Tabulates frame size and book price for ac motors, from ¾ to 125 hp. Covers dripproof and totally enclosed fan-cooled squirrel-cage, horizontal motors. General Electric Co, Schenectady 5.

Circle 357 on Reader Service Card

PHOSPHOR BRONZE—Handbook, 18 pp. Updated catalog explains continuous casting and includes information on phosphor bronze wire, bears, rods, strip, sheets, circles and special shapes. Gives specifications on six phosphor bronze alloys. Riverside-Alloy Metal Div, H K Porter Co Inc, Riverside, NJ.

Circle 358 on Reader Service Card

INDUSTRIAL FELT—Booklet, 8 pp. Describes some uses of 800 types of industrial and decorative felts. Felt application guide lists areas of general felt usage, then enumerates recommended felt for each application. American Felt Co, 2 Glenville Rd, Glenville, Conn.

Circle 359 on Reader Service Card

TOGGLE SWITCHES—Bulletin, 2 pp. Describes 20-amp toggle switches, with electrical ratings, circuitry, construction information, dimensions, operating characteristics and various mounts and terminals available. Electrical Div, McGill Mfg Co Inc, Valparaiso, Ind.

Circle 360 on Reader Service Card

SINTERED NYLON PARTS—Bulletin BR-1111, 4 pp. Lists formulations available and their applications as parts for bearings, rollers, cams and general-wear parts. Halex Corp, sub of Polymer Corp, 2120 Fairmont Ave., Reading, Penna.

Circle 361 on Reader Service Card

STOCK SPRING DEVICES—Bulletin 310f, 2 pp. Describes characteristics, specifications and prices of stock spring devices. With photos and line drawings. Hunter Spring Co, Div of American Machine & Metals Inc, 1 Spring Ave, Lansdale, Penna.

Circle 362 on Reader Service Card

DRY MAGNETIC-PARTICLE CLUTCH—Bulletin 6106-5, 4 pp. Includes information on construction and operational features of 10 ft-lb clutch, dimensions and specifications, performance curves on heat dissipation and torque trans-

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NATIONAL COVERAGE

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The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

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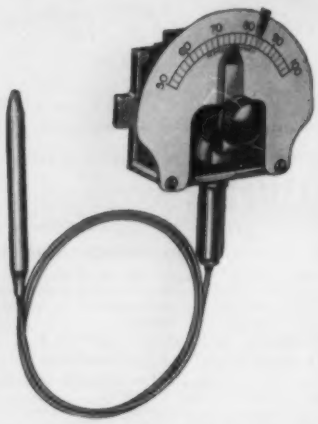

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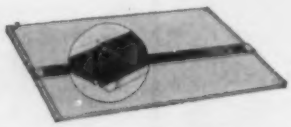

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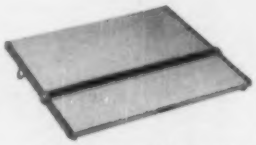

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PRODUCT ENGINEERING
330 W. 42 St., New York 36

mission, and cutaway drawings illustrating operating principle. Vickers Inc, Electric Products Div, St Louis 3.

Circle 363 on Reader Service Card

MINIATURE EXTENDED INNER RING BALLBEARINGS—Data sheet 6007, 2 pp. Gives dimensional and performance specifications for miniature extended inner ring bearings manufactured to precision tolerances of ABEC class 5 and better. Miniature Precision Bearings Inc, Precision Park, Keene, NH.

Circle 364 on Reader Service Card

LOW-PRESSURE CARTRIDGE RELIEF VALVE—Data sheets, 3 pp. Feature pressure curves, dimensions and specifications of direct-acting valve. Fluid Regulators Corp, 313 Gillette St, Painesville, Ohio.

Circle 365 on Reader Service Card

NYLON HOSE FITTINGS, ASSEMBLIES—Bulletin, 4 pp. Contains selector for nylon pressure hose and information on reusable fittings. Polymer Corp of Penn, 2140 Fairmont Ave, Reading.

Circle 366 on Reader Service Card

STEEL, CAST IRON COLLARS—Bulletin 2638, 4 pp. Specifications on all sizes up to 4⅛ in. bore dia. Illustrations indicate several typical uses. Standard Pressed Steel Co, Box 545 Jenkintown, Penna.

Circle 367 on Reader Service Card

The above stamp was released August 28, 1960, coinciding with the opening of the first World Congress ever held in the United States by the International Society for the Welfare of Cripples.

REPRINTS

Reprints currently available without charge are listed on the Reader Service Card bound in this issue. Single copy free; quantity prices on request.

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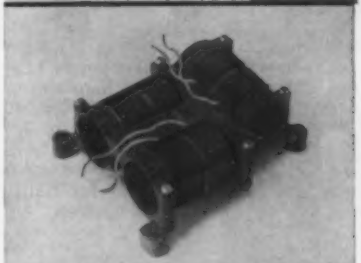

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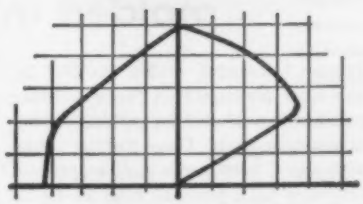

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DE-260

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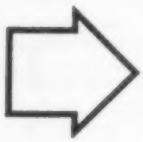

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359—Industrial Felt, 8 pp, American Felt Co.

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367—Steel, Cast Iron Collars, 4 pp, Standard Pressed Steel Co.

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357—Motor Selection Guide, card, General Electric Co.

THIS WEALTH OF VITAL INFORMATION . . .

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GENERAL ENGINEERING

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RESEARCH AND TEST EQUIPMENT

333—Strain-gage Waterproofing Kit

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306—Thermoformed Plastic Cushioning
325—Solid Urethanes
328—Reinforced-plastic Shapes
333—Strain-gage Waterproofing Compounds

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320—Unplasticised PVC Ball Valve
331—Direct-printed Circuits

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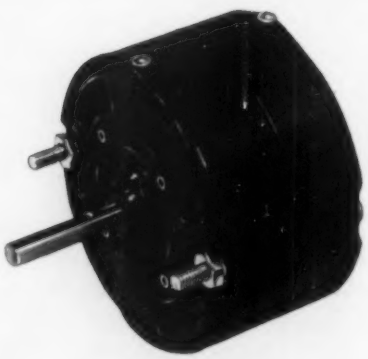

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